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EFFECT OF CONTRALATERAL MASKING PARAMETERS ON DIFFERENCE LIMEN FOR INTENSITY

Leslie J. Peters

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This study investigated the effect of narrow band and wide band contralateral masking using different overall sound pressure levels (SPL) on a difference limen (threshold) for intensity task. Specifically, the narrow band of masking was created by passing white noise through a 1/10 octave filter. The wide band of masking was created by passing this noise through a 1/3 octave filter.

Thirty-six adults (21 female, 15 male) with a mean age of 26 years participated in the study. Their responses were analyzed using an analysis of variance with repeated measures design and appropriate follow-up procedures. The following experimental questions were asked:

1. Does the presence of contralateral masking influence a subject's ability to detect small changes in intensity?

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2. Is a subject's ability to detect small changes in intensity affected from one test day to another test day?

3. Is a subject's ability to detect small changes in intensity affected when the bandwidth of the contralateral masker is held constant and the SPL of the masker is varied?

4. Is a subject's ability to detect small changes in intensity affected when the overall SPL of the masker is held constant and the bandwidth of the contralateral masker is varied?

5. Is a subject's ability to detect small changes in intensity affected when both the overall SPL and bandwidth of the contralateral masker are varied?

6. Does the presence of contralateral masking at lower levels (30 and 36 dB SPL) have the same influence on a subject's ability to detect small changes in intensity as contralateral masking presented at higher levels (50 and 56 dB SPL)?

The results of the study indicated that:

1. Contralateral masking influenced a subject's ability to detect small changes in intensity.

2. These masking effects did not change significantly ($\underline{p}<.05$) from Day 1 to Day 2 of the experiment.

3. When the overall SPL was changed by 6 dB and the bandwidth held constant at either 277 or 926 Hz, no significant difference was discovered in the ability to detect small incremental intensity changes.

4. When the masking bandwidth were varied and the overall SPL was held constant, a significant difference occurred. The wide band masking conditions were all more sensitive than the narrow bandwidths with the same SPL.

5. When the bandwidth and the overall SPL of the contralateral masker were varied, a significant difference occurred. The narrow bandwidth condition produced an inhibitory effect, while all wide and SPL masking conditions resulted in enhanced ability to detect small incremental intensity changes.

6. The experiment demonstrated that the wide band masker appeared to widen the ipsilateral critical band at 4000 Hz and that this pattern held for the four levels (30, 36, 50, 56 dB) of wide band masking presented in the study.

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INTRODUCTION

The smallest change in intensity[1] that can barely be detected by the human ear is known as the difference limen for intensity (DLI). The DLI can be expressed as a relative or an absolute value. The absolute DLI is the amount of change in stimulus magnitude required for a person to report that one stimulus is just noticeably different from another. The relative DLI is a ratio between the amount of change in one stimulus which is just noticeably different from the level of a reference stimulus (Durrant & Lovrinic, 1984).

The DLI can also be thought of as one way in which the auditory system resolves acoustic stimuli. The DLI has been proposed as a diagnostic test to help differentiate between types of hearing loss. Dix, Hallpike, and Hood (1948); Jerger, Shedd, and Harford (1959); and Ward (1968) have reported differences between subjects with normal thresholds and those with sensorineural hearing loss in DLI tasks. Bienvenue and Michael (1980) proposed the DLI as one part of a test battery for early detection of changes in the peripheral hearing mechanism.

The use of the DLI in psychoacoustic and diagnostic audiology studies has met with mixed results. The most consistent observation is high intrasubject variability resulting from a number of variables. One such variable is contralateral masking.

The present study evaluated the influence of intensity and bandwidth of a contralateral masker on a DLI task.

STATEMENT OF THE PROBLEM

The purpose of this study was to investigate the effect of narrow and wide band contralateral masking on the DLI. The following experimental questions were evaluated:

1. Does the presence of contralateral masking influence DLI?
2. Is DLI stable over time (days)?
3. Is DLI a function of the SPL of a contralateral masker?
4. Is DLI a function of contralateral masker bandwidth?

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[1] In this research, the term intensity is used to refer to a level of loudness. The correct definition of sound intensity is "the average rate at which sound energy is transmitted through a unit area normal to the direction of sound propagation." Sound intensity can be expressed in terms of a level in decibels referenced to $10B^{-12}$ w/m^2.

5. Is DLI affected when both the overall SPL and band width of the contralateral masker are varied?

6. Does the presence of contralateral masking at lower levels (30 and 36 dB SPL) have the same influence on a subject's ability to detect small changes in intensity as contralateral masking presented at higher levels (50 and 56 dB SPL)?

BACKGROUND OF THE PROBLEM

Early Research

Weber's research in 1834 was concerned with the human response to changes in physical stimuli. He theorized that just noticeable differences (JNDs) to any physical stimulus were perceived according to a proportionate change in the physical stimulus (Hirsh, 1952). That is, for a stimulus to be one JND from another stimulus, the increment of difference was a constant fraction of the total stimulus. This resulted in Weber's constant ratio law.

Fechner theorized that a stimulus was a perception that could be expressed along a psychological scale based on discrete sensory units. That is, a tone of 50 dB may or may not be twice as loud as a tone of 25 dB; however, a tone perceived as 50 JNDs above threshold would sound twice as loud as a tone 25 JNDs above threshold (Hirsh, 1952). Although Fechner's theory has been shown not to hold with increasing intensity, the theory does represent a variable in DLI measurement. That is, DLI varies as a function of sensation level (SL).

Knudsen (1923) was one of the earliest researchers to investigate DLI. He used a telephone receiver to transduce tones from 30 to 20,000 Hz having an intensity range that varies from just barely audible to the threshold of pain. Each subject was asked to hold the earphone tightly against his ear and to indicate when a flutter (created by two tones that were alternating at a rate of 50 times per minute and equal in duration) became a steady state tone and when a flutter was heard as the intensity was increased from subthreshold levels. Knudsen (1923) reported that for moderate to high intensity levels, the Weber law held. At low intensity levels, however, the Weber law was inversely related to a logarithmic function of intensity. A drawback of Knudsen's work concerned the reliability of the measurements because the oscillator created contact noises when it operated.

Riesz (1928) conducted research on the DLI which has come to be known as the classic study. Riesz combined two tones of equal intensity which differed in frequency by three cycles. This created a difference tone with a three-cycle modulation or beat that did not contain transients. His subjects ($\underline{N}$ = 12) were asked to signal when the beating pattern in the stimulus was not present. This was done as a function of frequency and intensity. Riesz discovered that a normal ear was capable of detecting .5 decibel (dB) changes over a wide frequency range at sensation levels greater than 60 dB. For any sensation level above 60 dB, regardless of frequency, the DLI was a constant value. As the sensation approached auditory threshold, however, the DLI value increased at different rates for the lower compared with the higher frequencies. Riesz compared the DLI values he discovered for the lower sensation levels with those reported by Knudsen (1923) and ascertained that his DLI were larger. This occurred because the equipment used by Knudsen created transients which provided cues to his subjects.

Tonndorf and Washburn (1955) also investigated the influence of switching transients on DLI values by using different stimuli. He discovered that a square wave yielded the smallest DLI compared with a triangular or sine wave. He concluded that a sine wave was the stimulus of choice for DLI tasks because it did not spread transient energy into frequency regions other than the sine wave fundamental.

Small (1959) also expressed concern about possible cues in DLI research. He explained that transients are side bands ot energy affected by the rise-fall time of the stimulus. The shorter the rise-fall time, the more energy present over a wide frequency range. Thus, "increasing the rise-fall time of a tone will decrease the transients present, while decreasing the rise-fall time broadens a tone's spectrum and lessens its purity" (p. 509).

Harris (1963) completed a series of studies investigating the DLI. One of his experiments evaluated the effect of rise-fall time on DLI. His results were interpreted to indicate that a stimulus with a short rise-fall time (<20 msec) created equal DLI values, whereas the DLIs decreased as the rise-fall time increased from 20 to 50 msec. The DLI did not change significantly when the rise-fall time was ≥50 msec.

As a result of his experiments, Harris (1963) reported that there were several types of DLI judgments. He stated that these judgments were testing different psychophysical parameters as well as being influenced by characteristics of the stimulus used. One type of DLI response was called the loudness memory factor because it required subjects to evaluate the loudness between two tones separated by a time interval. Another, called the loudness modulation factor, required subjects to judge if a tone was fluctuating in loudness as the tone was varied in intensity. The third type of DLI was called the loudness masking factor because it required subjects to indicate when a steady state tone contained an intensity increment. Harris detected no statistically significant difference between DLI with the loudness masking and loudness modulation experimental tasks. The DLI using a loudness memory task was significantly different from the other tasks, however. As a result, Harris concluded that the incremental procedure used by Knudsen (1923) and the modulation technique used by Riesz (1928) were different auditory tasks for evaluating DLI.

Subject Reliability

A common variable for DLI is intrasubject and intersubject reliability. Montgomery (19[illegible]) indicated that DLI scores varied within subjects from trial to trial. He reported that these variations were not under the control of the experimenter and listed the following reasons for intrasubject variability: (a) difference in sharpness and steadiness of attention, (b) the presence of a disturbing background of auditory imagery, (c) changes in the acuity of the hearing mechanism, and (d) head noises.

Further, Montgomery (1935) was of the opinion that inherent variation within and among subjects required the experimenter to have a standard or criterion for measuring the subject's response. He also thought that the most accurate DLI could be obtained by requiring subjects to guess. The point where most errors began could be considered the DLI threshold. Dimmick and Olson (1941) also listed subject response options as a source of variation in their DLI results.

Durrant and Lovrinic (1984) reported that the DLI criterion must include a statement of the psychophysical procedure, the percent of correct or incorrect responses that will determine threshold, the judgmental criterion, and the instructions given to the subject.

Procedural Reliability

Tonndorf and Washburn (1955) used an 800-Hz tone at a 10-dB sensation level to investigate the effect of ascending versus descending DLI procedures. One-dB steps were used in the ascending and descending trials. The ascending was initiated above DLI threshold and the descending was initiated below the DLI threshold. Of the 58 subjects completing the paired comparison, 17 exhibited smaller DLIs for ascending thresholds, six showed no difference, and 35 had smaller DLIs for descending thresholds. They concluded that small DLIs occurred when a descending technique was used.

Harris (1963) evaluated procedural differences for the DLI. His purpose was to find an optimum set of conditions that would produce a stable DLI. Four subjects were evaluated 75 times and were allowed to control the test stimuli. Using average values for his optimum DLI, Harris reported that the absolute size of the DLI was small and that there was no frequency (125 to 6000 Hz) effect. He also stated that the overall effect of loudness on DLI was minimal except at very low levels. He concluded that the different DLIs discovered by Knudsen (1923) and Riesz (1928) resulted from stimulus differences.

Influence of Sensation Level

Harris (1963) also investigated the effect of sensation level and the rise-fall time with increment duration. His results indicated that as the sensation level of the increment duration increased, there was a corresponding decrease in the DLI. This effect reached a plateau at 300 msec regardless of the sensation level; beyond 300 msec, the effect of rise-fall time was not significant.

Influence of Masking

Zwislocki, Pirodda, and Rubin (1959) reported auditory threshold changes as a function of on/off times of masking tone with and without transients. A 100-Hz tone with a 20-msec duration followed an ipsilateral masking stimulus by 40 msec. The threshold shift for a masker using a gradual on/off slope was an average of 30 dB. As the duration of the masker was increased, the threshold shift was reduced. When they used an abrupt cutoff with the same masking paradigm, only a 10-dB threshold shift was reported (when no audible transients were present). As the masking stimulus duration was lengthened, the two conditions were reversed. The effect seemed to become independent of interval beyond 100 msec. They speculated that in DLI testing, if one pure tone were followed by another (less than 100 msec apart), the DLI would be influenced by the masking conditions. This report seems to substantiate that of Harris (1963) who reported that procedures dictate the type of DLI obtained.

Clinical Applications

Fowler (1936) described a test, known as the Alternate Binaural Loudness Balance (ABLB), as a means of early diagnosis of otosclerosis. Although the test did not prove useful in diagnosing otosclerosis, some of his subjects with sensorineural hearing loss showed an abnormal result. Fowler used the term "recruitment" to describe this result which was an abnormal growth in loudness. Consequently, early research in the clinical area using the DLI was concerned with detecting the presence or absence of recruitment. Bekesy (1947) described a research audiometer and reported that very small threshold tracing variations could be considered a recruitment in subjects with a sensorineural hearing loss.

Hirsh, Palva, and Goodman (1954) disputed Bekesy's assumption that recruitment could be indirectly measured by his self-recording audiometer. They reported that clinicians who used the DLI measures were assuming that cochlear disorders would result in smaller DLI measures and that a recruiting ear should exhibit smaller DLI than a normal ear at equal presentation levels. Bekesy's assumptions were summarized by Hirsh et al. (1954):

> It is assumed that since the loudness change corresponding to a given intensity change is much greater in a recruiting patient, the sensitivity to changes in intensity must be better (i.e., the DL must be smaller). Second, since the classic data on differential sensitivity show that the size of the DL in normal persons decreases as the intensity at which it is measured is increased, it is assumed that the DL at a given intensity will be smaller for a recruiting patient than for a nonrecruiting patient, because the loudness associated with that intensity by the recruiting patient is greater. (p. 526)

Hirsh et al. (1954) were not in agreement with these assumptions and stated:

> Twice loudness is NOT equal to twice as many DL's. In normal hearing, the loudness for low tones increases more rapidly than does the loudness for middle frequency tones; but the DL for low tones is larger, not smaller, than it is for middle frequency tones. (p. 531)

The arguments raised by Hirsh et al. (1954) contributed to the lack of use of the DLI as a clinical tool. The lack of intersubject or intrasubject variability appears to be the main reason for the lack of clinical acceptance, however.

Luscher and Zwislocki (1948) reported that clinical DLI tests could be made more reliable. They used an amplitude-modulated steady state tone and presented it at 40 dB SL. They reported that normal hearing subjects obtained a DLI score between 12% and 18%, subjects with a conductive hearing loss demonstrated a DLI between 10% and 16%, and those with a sensorineural loss had DLI scores of less than 8%.

Denes and Naunton (1950) reported that according to past research, the DLI should be small near threshold in a recruiting ear and remain small as intensity increased. They employed a paired tone comparison procedure and measured the DLI at two sensation levels. In this way, the patient was his own baseline rather than being placed into a predetermined group. They felt that recruitment could be inferred if the DLI obtained close to threshold (4 dB SL) was equal to or smaller than the DLI at higher sensation levels (44 dB SL).

Denes and Naunton reported that aside from technique, a major problem with the work of Luscher and Zwislocki (1948) was that the sinusoidal modulation created sidebands that the patient could use as cues; Harris (1963) made the same observation.

The results reported by Denes and Naunton (1950) failed to clearly differentiate between recruiting and nonrecruiting subjects. Some of the DLI values at the high sensation level (44 dB SL) were greater than values for subjects with conductive hearing losses. This fact was also a rejection of earlier Luscher and Zwislocki (1948) data.

Lund-Iverson (1952) repeated the Luscher and Zwislocki procedure with a much larger sample population. The results did not yield significantly different DLIs among normal hearing, conductive, and sensorineural hearing loss patients. These results disputed the earlier work of Luscher and Zwislocki (1948).

As a result of the many differences obtained from several studies, it cannot be assumed that DLI values can be used as a measure of recruitment.

Jerger reported work on a clinical test for recruitment in 1952 and 1953. His first test was a modification of the Luscher-Zwislocki paradigm. However, Jerger presented his modulating tone at 15 instead of 40 dB SL. He also modified the Denes-Naunton test by presenting a tone at 10 and 40 dB SL (as opposed to 4 and 44 dB SL). Jerger thought that by comparing the patient to himself, as in the Denes-Naunton method, the variability between subjects could be eliminated. Jerger (1953) examined 18 patients with this technique and stated that it worked well clinically.

The Short Increment Sensitivity Index (SISI) (Jerger, Shedd, & Harford, 1959) was described by Jerger as a site of lesion test rather than an indirect or direct measure of recruitment. Performance on the SISI test yields a score from 0% to 100%. Zero percent means that none of the 1-dB increments were heard, while 100% indicates that all of the 1-dB increments were detected. Jerger reported that a cochlear lesion would be indicated by a SISI score of >60%. Although Jerger did not present the SISI as a classic DLI test, he reported that it measured the ear's ability to detect small increments in loudness and that the SISI measured the cochlea's ability to respond to a transient signal of small amplitude and was an indicator of cochlear pathology.

Matkin and Carhart (1966) described conditions other than those that would cause a cochlear site of lesion, and recruitment was discerned to be part of the clinical findings. Thus, recruitment is not necessarily a cochlear phenomenon, even though most patients with a known cochlear lesion may demonstrate recruitment.

In 1975, Tracor Instruments introduced the RA 207 audiometer. It was built to evaluate the site of lesion using the Minimal Auditory Intensity Differential (MAID) procedure (Dalton & Boehm, 1972). The hope was to separate patients as having either a cochlear or retro-cochlear pathology. The MAID procedure required patients to identify a 4-second warble in a tone presented at 20 dB sensation level. The increment or warble was initially presented at 5 dB and decreased until no longer heard. Then the procedure was reversed. Presentations were 5, 4, 3, 2.5, 2, 1.5, 1, .75, .5, and .25 dB. The MAID threshold was considered to be the intensity increment where the warble reappeared. Dalton et al. (1972) performed an acoustic analysis of the RA 207 signal and detected transient energy at 4000 Hz and above. It should be remembered that earlier authors (Harris, 1963; Montgomery, 1935) had pointed to abrupt signal switching as an important variable in DLI testing. Although Tracor's instruction manual described the audiometer as having no audible transient energy, the MAID RA 207 did not prove reliable in field trials and was withdrawn from production.

Susceptibility

Early investigations evaluating susceptibility to hearing loss focused on the aspect of a change in threshold sensitivity. Temporary threshold shift (TTS) was offered by Ward (1968) as a measure of predicting permanent threshold shift (PTS). Ward felt that the best predictor of PTS was the TTS that resulted from exposure to the same noise environment. This would indicate that no one single noise source could be used as a predictor of hearing loss.

Bienvenue, Violon-Singer, and Michael (1977) and Bienvenue and Michael (1980) proposed that the integrating properties of the ear within a given frequency range could provide an early indication of a change in hearing which is more stable over time than TTS. They used a DLI procedure to demonstrate a difference between normal hearing subjects exposed to a noise source and other normal hearing subjects who had not been exposed.

Theoretical Aspects

Matkin and Carhart (1966) proposed that selective damage at the level of cochlear nuclei could yield results that had previously been associated with cochlear pathology (i.e., recruitment). Although the reported changes were from animal studies, it does question whether all increased ability to recognize changes in intensity should be considered cochlear. If these lesions of the central auditory pathway at the level of the cochlear nucleus can affect a DLI score, then perhaps variables other than procedural and methodological should be considered in efforts to describe changes in DLI ability.

Morest (1982) summarized the last 20 years of data pertaining to central auditory degeneration following noise exposure. He said that it would appear degeneration may occur in nerve endings in the cochlear nucleus and related parts of the superior olivary. He suggests that direct stimulation of the eighth nerve may not eliminate responses caused by cochlear pathology because of pathological central pathways.

As a result of experimental evidence confirming the fact that high noise exposure can often lead to central pathology and since there are many points of neural crossover in the auditory pathways beyond the cochlea, it would follow that the DLI could be affected by binaural stimulation.

Contralateral Masking

There are two pathways by which the DLI for intensity can be influenced by contralateral masking: (a) when the tone or noise presented to one ear is loud enough to influence the other ear (overmasking) resulting in an elevation of the test ear threshold, and (b) central masking, a condition in which the threshold of one ear is elevated by the presence of a masker in the contralateral ear that is too low for overmasking to occur.

Central Masking

Wegel and Lane (1924) were the first to describe what has become known as central masking. They discovered that the threshold in the test ear was elevated when a low level contralateral stimulus was present in the contralateral ear. They theorized that the threshold shift occurred because of interference in the central nervous auditory system.

Dirks and Malmquist (1965), using Bekesy fixed frequency techniques, studied air conduction threshold shifts for pulsed and steady pure tones produced by a continuous contralateral masker (a narrow band masker centered at 4000 Hz). Of the test frequencies, the greatest threshold shift occurred at 4000 Hz. At 70 dB of masking, the mean change for pulsed tracings was .91 dB and for continuous it was 6.66 dB. They also reported that excursions in the latter tracing were reduced by 30% during contralateral masking stimulation.

Frank (1977) evaluated the effect of central masking as a function of frequency, type of masker, and effective masking level (EML). He reported that regardless of frequency and masking condition, a 5-dB correction is needed for effective masking levels of 30 to 40 dB, and a 10-dB correction would be required above 40 dB EML; at EMLs of 20 dB or lower, however, no correction was needed.

Contralateral Masking with SISI and Bekesy Results

Blegvad and Terkildsen (1967) reported on contralateral masking and the SISI test using normal hearing listeners. A white noise of 50, 70, and 90 dB SPL was chosen as the contralateral masker. Twenty presentations at 1- and 3-dB increments were given at each SPL level. The 50% point, which indicated the intensity of an increment to which the subject responded half of the time, was chosen to denote the DLI. A significant decrease in increment size was discovered for each increased level of contralateral masking.

Dirks and Norris (1966) compared the effect of various ipsilateral and contralateral maskers on Bekesy fixed frequency tracings in normal hearing listeners. Their study included continuous and interrupted wide band and narrow band noise, as well as pure tone maskers, presented at 40 dB SPL. The results indicated a reduction in tracing size for broad band white noise condition.

Blegvad (1968) summarized his work on the SISI and influence of contralateral masking. Briefly, he discovered that higher frequencies demonstrated more effect than low frequencies, with 4000 Hz being influenced the most; continuous masking in the contralateral ear provided a greater influence on increment detection than interrupted masking; and a direct contralateral masker provide more masking than a remote masker.

Shimizu (1968) also confirmed that the SISI performed at 4000 Hz was more influenced by the contralateral masking condition than a SISI at 500 Hz. Specifically, he discovered that 5 of 10 normal hearing subjects produced a positive SISI at 4000 Hz with a contralateral masking stimulus of 40 dB SL white noise. Shimizu reported that central masking or adaptation could not directly explain the increased sensitivity.

Peters (1985) reported the results obtained for a DLI procedure in which a contralateral masker of various intensities was employed. Using a quantal method, a procedure which places an increment of sound on a steady background of noise, subjects reported the number of intensity increases heard from a possible 10 presentations. Twenty normal hearing listeners were asked to identify the presence of the intensity increase in a continuous 4000-Hz tone presented at 20-dB SL. A contralateral masking stimulus, consisting of a 1/10 octave filtered white noise centered at 4000 Hz was presented at 30-, 50-, 70-dB SPL. The results were compared with those obtained during a quiet condition. A general trend was discovered: (a) smaller increment detection occurred with all levels of contralateral masking than during the quiet (no masking) condition, and (b) all subjects demonstrated an increase in DLI as a function of increased intensity of the masker. The level at which this occurred was not constant among subjects.

Contralateral Masking and the DLI

Paul and Barry (1972) looked at the nature of an apparent increase in DLI using a quantal approach. A test tone containing the intensity increment was presented at 60 dB. A contralateral masker was also presented at 60 dB either continuously or interrupted. The continuous noise pattern resulted in a smaller DLI at 4000 Hz, while the interrupted pattern resulted in a significant increase in size.

Paul and Barry (1972) then repeated the experiment using the same eight subjects but with various delays in the masking tone. Under all conditions of delay, the DLIs obtained with contralateral stimulation were larger than those obtained in quiet. Paul reported that adaptation of the neural activity might be a cause of the contralateral effect. He wrote that the interrupted stimulus pattern may allow the neurons time to recover. However, "during the continuous background condition, the neural activity soon would subside into a net inhibitory effect so that increment detection may be enhanced by virtue of reduction of neural activity" (p. 385).

Peters (1986) evaluated the effect of familiarization (days of the week), the contralateral masking parameters of bandwidth and intensity, and the size of the intensity increment on the ability to recognize small increases in intensity. He did not discover any significant interactions. Therefore, differences occurred as a direct result of significant main means.

Days of the week did not differ significantly. This indicated that the results recorded on Monday were essentially the same as those recorded on Friday (the last day of the experiment). The difference limen task, while it differed from subject to subject, exhibited a stable pattern per subject over time.

The main effect of contralateral masking was significant. Since contralateral masking did not interact significantly with either other factor, it may be concluded with a 95% confidence that small intensity increment detection varied directly as a function of contralateral masking.

The main effect of increment size was also significant. As there was no significant interaction with either of the other main means, it may be concluded with a 95% confidence that small intensity increment detection varied directly as a function of increment size.

Follow-up statistics using Tukey's Wholly Significant Difference (WSD) were calculated on all possible contrasts of contralateral masking. The narrow band masking conditions were not significantly different from themselves or the quiet no-masking condition. The wide band masking conditions were not significantly different from themselves. Both wide band conditions were significant when compared to either narrow band condition, however.

The experimental design was constructed so that masking comparisons might indicate the way in which the ear was responding to contralateral masking stimuli during a difference limen for intensity task; narrow band higher energy condition produced less effect than the wide band lower energy conditions. Further evidence of the importance of bandwidth was provided by looking at contrasts which varied energy with constant bandwidth. No significant difference was detected.

When energy in the masker was held constant and bandwidth varied, a significant difference between wide and narrow band maskers was seen. This indicated that the ear used bandwidth for discrimination of small intensity increments.

Summary

This section has reviewed the literature on the difference limen for intensity. In summary, it can be stated that (a) the size of the DLI depends on the method by which it is measured; (b) variations in size have been noted across frequency and sensation level; (c) recruitment may or may not be associated with an abnormally small DL for intensity; (d) data were reviewed that questioned the clinical value of the DLI as a site of lesion test; and (e) the effects of contralateral masking on the difference limen for intensity were also reviewed and factors thought to influence results were listed.

PROCEDURES

General

DLI was measured in 36 subjects for several experimental conditions (quiet, four levels of 1/10 octave contralateral masking, and four levels of 1/3 octave contralateral masking). Both 1/10 and 1/3 octave maskers were presented at 30, 36, 50, and 56 dB SPL. In each test condition, the detection of seven intensity increments was measured. The increments were counterbalanced, and the test frequency was fixed at 4000 Hz.

Subjects

Thirty-six adults (21 female, 15 male) participated in this study. The subjects' mean age was 26 years (standard deviation [SD] 5 years, range 22 to 40 years), and all subjects were paid for their participation. Each subject was evaluated before selection and at the beginning of each test day to ensure normal hearing sensitivity (-10 to 10 dB hearing level [HL] bilaterally from 250 to 8000 Hz referencing ANSI-S3.6-1969) and no greater than a 5-dB difference between ears at any one test frequency. No subject had a history of high noise exposure or tinnitus as determined by interview. All subjects were asked to refrain from recreational noise exposure (shooting, riding motorcycles, wearing stereo headphones) during their participation. All subjects agreed to participate and sign informed consent forms and forms explaining the study as required by the Pennsylvania State University's policy for using human subjects in research.

Instrumentation

All testing was performed in an audiometric test booth having a low ambient noise level suitable for open ears testing (ANSI S3.1-1977).

Each subject's pure tone air conduction thresholds were tested with clinical audiometers (Madsen OB-822; Maico MA-24) which met ANSI S3.6-1969 specifications. This was done to ensure that each subject met the hearing sensitivity requirements needed for participation.

Figure 1 illustrates a block diagram of the test instrumentation. An audiometer (Maico MA-20) was used to generate 4000 Hz test tone and white noise. The test tone output was routed to a 2-dB step attenuator (custom built) and then to a difference limen (DL) unit. The DL unit was custom built with solid state circuitry and photo-electric switches to eliminate transients and increase stability. The DL unit imposed an intensity increment on the 4000-Hz tone ranging from 1.6 to .4 dB in .2-dB discrete steps (having a 50-msec rise/fall time and overall duration of 200 msec). The 4000-Hz tone was chosen as the test frequency because previous research on the SISI test (Blegvad, 1968; Shimizu, 1968) had reported the greatest influence of contralateral masking at that frequency. The 0.2-dB step increment size was chosen to match previous ipsilateral DLI measurements conducted by Bienvenue and Michael (1980). The output of the DL unit was monitored with a voltmeter (Hewlett-Packard 400 SL) and directed to a TDH-39 earphone mounted in an MX 41/AR cushion in the test booth.

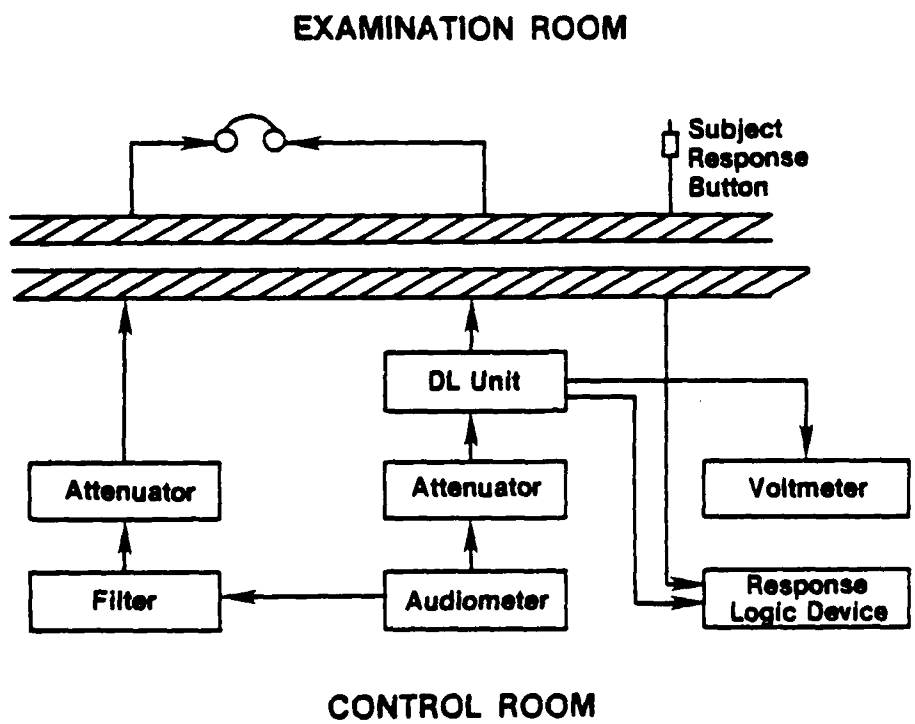

Figure 1. Instrumentation block diagram.

Both contralateral masking stimuli were developed from the white noise output of the MA-20 audiometer. The wide band masker was designed to have a bandwidth greater than the critical band at 4000 Hz. The narrow band masker was designed to have a bandwidth less than the critical band at 4000 Hz (Scharf, 1959). To accomplish this, the white noise (having equal energy per cycle) was directed to a sound and vibration analyzer (General Radio 1564-A) which acted as a 1/10 or 1/3 octave band filter centered at 4000 Hz. When set to the 1/10 octave mode, a narrow bandwidth of 277 Hz and a slope of 40 dB per octave resulted. When set to the 1/3 octave band mode, a bandwidth of 926 Hz and a slope of 30 dB per octave resulted. The analyzer was not in line during presentation of the quiet test condition. The output of the analyzer was directed to a 1-dB step attenuator (custom built) and then to a TDH-39 earphone mounted in an MX 41/AR cushion.

The output of the DL unit was also directed to a subject response logic device (RLD). The RLD was activated by the onset of the increment from the DL unit. This activation opened a response gate for 1000 msec. If the subject heard the increment, he responded by pressing a button directed to the RLD. If the subject responded within the 1000-msec window, the response was counted and displayed in the RLD. If the subject responded outside the 1000-msec window, however, the response was not counted (detected) by the RLD.

The instrumentation was calibrated for each subject before, midway through, and after data collection.

Procedures

A quantal method was used as the psychophysical test procedure. In this method, a constant stimulus (4000 Hz pure tone) was heard in the test ear and the intensity increment to be identified was overlaid on the background presentation. The result was a constant tone with intensity increments.

An experimental schedule was developed for each subject. The schedule listed a counterbalanced test order for the masking conditions which were (a) quiet, no contralateral masking; (b) narrow band contralateral masking with overall SPL of 30, 36, 50, and 56 dB; and (c) wide band contralateral masking with overall SPL of 30, 36, 50, and 56 dB.

Since there was never a difference in threshold between a subject's ears greater than 5 dB at 4000 Hz, each subject's test ear was always the right ear and the contralateral masking was always directed to the left ear. The subject's task was to press a response button every time he heard an increment in loudness. Appendix A presents a set of instructions that were given to each subject. By requiring the subject to make a forced choice (yes, I hear it, or no I don't), a more definite response pattern emerged.

The subjects always heard a 4000-Hz test tone at 20 dB SL. The increments which subjects detected were overlaid on the 4000-Hz tone. For example, if the subjects heard a 1.6-dB increment, they were responding to a change in the 4000-Hz test tone of from 20 to 21.6 dB SL.

The subjects were always presented with the highest level increment (1.6 dB) first and then presented with progressively smaller increments in .2-dB steps (down to .4 dB) for each condition. Each increment (1.6, 1.4, 1.2, 1.0, .8, .6, .4) was presented 10 times, and the number of increments heard was recorded as the subject's score for hearing that increment size. The DL unit was programmed to randomly present the increment with an intrastimulus interval of 2000 to 5000 msec.

The presentation level for each test condition was maintained at 20 dB SL. This level was selected to be far enough above threshold to allow the test tone to remain audible over the course of each experimental session.

Each subject was given a 5-minute warmup session before data collection and additional practice time until he or she could perceive five consecutive increments at 1.6 dB in quiet. During the actual test presentations, the subject was given a chance to listen to three presentations of the 1.6-dB increment before each successive test condition. In this way, the subject received a target to enhance concentration and elevate performance. Subjects were given a 1-minute rest after the first, second, and fourth test conditions. A 3-minute rest was given after the completion of the third test condition.

RESULTS

Introduction

This study investigated the influence of contralateral masking during 2 test days. A subject's ability to identify the presence of 10 intensity increments originating from a continuous 4000-Hz background tone was measured using nine contralateral masking conditions and seven increment sizes. Specifically, the nine levels of contralateral masking were differentiated by overall sound pressure level (SPL), level per cycle (LPS), and bandwidth. The nine contralateral masking conditions were quiet (Q), narrow band masking of 277 Hz at 30 dB SPL (N30), narrow band masking of 277 Hz at 36 dB SPL (N36), wide band masking of 926 Hz at 30 dB SPL (W30), wide band masking of 926 Hz at 36 dB SPL (W36), narrow band masking of 277 Hz at 50 dB SPL (N50), narrow band masking of 277 Hz at 56 dB SPL (N56), wide band masking of 926 Hz at 50 dB SPL (W50), and wide band masking of 926 Hz at 56 dB SPL (W56). The seven levels of increment size were 1.6, 1.4, 1.2, 1.0, .8, .6, and .4 dB. The test days for the experiment were Day 1 and Day 2. Day 2 also served as a retest comparison. All of the subjects ($\underline{N}$ = 36) received every condition.

Descriptive Statistics[2]

The mean number of increments identified, collapsed during the nine contralateral masking conditions and the seven increment sizes, was 4.74 for

[2]The raw data for each test condition are shown in Appendix B.

Day 1 and 4.87 for Day 2. The mean number of increments identified was based on 2,268 observations (nine contralateral masking conditions times seven increment sizes times 36 subjects). The standard deviation was 1.87 for Day 1 and 1.67 for Day 2. Thus, the subjects' performance for Day 1 and Day 2 was similar.

Table 1 lists the mean, standard deviation, and range scores for the number of increments identified at each level of contralateral masking collapsed over increment size and test day. The means and standard deviations were calculated on 504 observations (seven increment sizes times 2 days times 36 subjects). The mean scores for all the narrow band masking conditions were smaller than the quiet condition; while the means for all the wise band masking conditions were larger than the quiet condition (see Appendix C). The standard deviations remained relatively constant across all the masking conditions. The range scores varied from a minimum of 0 to a maximum of 10 for each masking condition.

Table 1

Mean, Standard Deviation, and Range of the Increments for Each Masking Condition, Collapsed Over Increment Size and Test Day (Number of Observations = 504)

	Masking conditions								
	Q	N30	N36	W30	W36	N50	N56	W50	W56
Mean	4.56	4.11	3.95	5.10	5.40	3.99	4.36	5.78	5.99
SD	3.47	3.62	3.59	3.62	3.62	3.61	3.58	3.59	3.47
Range	10-0	10-0	10-0	10-0	10-0	10-0	10-0	10-0	10-0

Table 2 lists the mean, standard deviation, and range scores for the number of increments identified for each level of increment size collapsed over all masking conditions and test days. The means and standard deviations were calculated on 648 observations (nine levels of contralateral masking times 2 test days times 36 subjects). As expected, the number of increments identified was related to increment size. The middle increment size (1.0 dB) resulted in the largest standard deviation, while the smallest and largest increment sizes (.4 and 1.6 dB) had the smallest standard deviations. The range varied according to the increment size.

Table 3 lists the means for the number of increments identified for each increment size, day, and contralateral masking condition. For both Day 1 and Day 2, the larger increment sizes resulted in higher mean scores than the smaller increment sizes, and the wider masking bandwidths resulted in higher mean scores than the narrow masking bandwidths.

Table 2

Mean, Standard Deviation, and Range of the Increments Identified for Each Increment Size, Collapsed Over Masking Condition and Test Day (Number of Observations = 648)

	Increment size in dB						
	1.6	1.4	1.2	1.0	0.8	0.6	0.4
Mean	8.80	7.93	6.64	5.00	3.08	1.56	0.63
SD	1.72	2.15	2.59	2.71	2.54	1.91	1.12
Range	10-2	10-1	10-0	10-0	10-0	8-0	7-0

Table 3

Means of the Increments Identified for Each Masking Condition, Reported for Each Increment Size and Each Test Day (Number of Observations = 36)

Size	Day	Quiet	N30	N36	W30	W36	N50	N56	W50	W56
1.6	1	8.78	8.17	7.56	9.00	9.36	8.14	8.36	9.53	9.58
	2	8.56	8.69	8.11	9.11	9.22	8.24	8.69	9.61	9.64
1.4	1	7.72	7.49	6.86	8.22	8.33	7.19	7.63	8.97	8.97
	2	7.78	7.14	6.97	8.06	8.72	7.22	7.67	8.72	9.11
1.2	1	6.22	5.58	5.50	7.00	7.61	5.67	6.41	7.75	7.86
	2	6.44	5.69	5.81	7.08	7.50	5.51	5.83	8.08	8.11
1.0	1	4.86	3.68	3.75	5.75	5.89	3.58	4.25	6.19	6.44
	2	4.88	3.61	3.78	5.72	6.06	3.79	4.44	6.31	6.83
0.8	1	2.78	1.97	2.17	3.17	3.53	1.92	2.22	4.17	4.38
	2	2.80	2.39	2.25	3.67	4.11	2.10	2.19	4.56	4.97
0.6	1	1.67	1.05	0.75	1.33	1.61	0.64	1.25	2.81	3.08
	2	1.31	1.17	0.86	1.81	2.33	0.74	1.11	2.08	2.86
0.4	1	0.22	0.38	0.44	0.67	0.50	0.33	0.44	1.19	0.92
	2	0.36	0.44	0.53	0.88	0.89	0.38	0.53	1.00	1.11

Table 4 lists the means for the number of increments identified for each contralateral masking and increment size condition collapsed over the 2 test days. Inspection of Table 4 reveals that the narrow band masking conditions resulted in lower means than either the quiet or any of the wide band masking test conditions regardless of increment size.

Table 4

Means of the Increments Identified for Each Increment Size, Collapsed Over Test Days, Reported by Masking Condition (Number of Observations = 72)

	Increment size in dB						
Masking Condition	1.60	1.40	1.20	1.00	.80	.60	.40
Quiet	8.67	7.75	6.33	4.88	2.79	1.24	0.29
N30	8.43	7.31	5.64	3.65	2.18	1.11	0.42
N36	7.84	6.92	5.65	3.76	2.20	0.81	0.47
W30	9.10	8.14	7.04	5.74	3.42	1.57	0.78
W36	9.29	8.53	7.56	5.97	3.82	1.97	0.69
N50	8.24	7.22	5.51	3.79	2.10	0.74	0.38
N56	8.53	7.65	6.13	4.35	2.21	1.18	0.49
W50	9.57	8.85	7.92	6.25	4.36	2.44	1.10
W56	9.61	9.04	7.99	6.64	4.68	2.97	1.01

Data Analysis

The raw data were analyzed using a three-factor completely crossed repeated measures analysis of variance (ANOVR) (Games, Gray, Herron, Pentz, & Sinatra, 1985). The null hypothesis stated that there would be no difference between the means associated with the different contralateral masking conditions, increment sizes, or test days.

The ANOVR assumption of sphericity or circularity of the variance covariance matrix was violated by the data. Specifically, for each subject, the larger increments were almost always heard, while the smaller increments were almost never heard. Because this assumption was violated, a $\hat{\lambda}$ adjustment was computed on some of the ANOVR results. An ANOVR companion program called PL23RM (Games, 1979) was used to create the $\hat{\lambda}$ values.

Table 5 lists a summary of the analysis of variance. The main effects of contralateral masking and increment size were significant ($p<.05$). The contralateral masking by increment size interaction was also significant ($p>.05$) and remained significant even after the $\hat{\lambda}$ adjustment. All other main effects and interactions were not significant ($p<.05$). Inspection of Figure 1 reveals that the contralateral masking by increment size interaction primarily occurred at the .4-dB increment size. The interaction was not important (see WSD Followup), however. The subjects' means for the increments identified at the nine contralateral masking levels were remarkably parallel, from the largest to the smallest increment size. Because there was no triple interaction and because the significant ($p<.05$) two-way interaction could be ignored, the two significant main effects were evaluated. These two main effects, contralateral masking and increment size, were analyzed by a statistical program called PVCVRL (Games, 1982) and then submitted to another statistical program called FOLUP (Games, Yancey, Howell, & Serapiglia, 1974). The results of FOLUP were all possible contrasts of these two main effects using Tukey's Wholly Significant Difference (WSD) test (Games et al. 1974).

Table 5

Analysis of Variance Summary

Source	Mean square	DF	F ratio	Critical value	Probability
Days (D)	16.92	1	.85		.362
Error	19.80	35			
Masking (M)	311.43	8	44.50		.0000[a]
Error	7.00	280			
Increment (I)	6494.40	6	676.70		.0000[a]
Error	9.60	210			
D x M	1.38	8	.29		.595
Error	4.79	280			
D x I	1.82	6	.63		.432
Error	2.87	210			
M x I	8.26	48	4.10	1.69[b]	<.05[c]
Error	2.02	1680			
D x M x I	1.27	48	.84		.365
Error	1.51	1680			

[a] $p<.05$.
[b] Critical value calculated from $\hat{\lambda}$ adjustment.
[c] Interaction although statistically significant, it is actually meaningless (see Figure 2 for graph of the M x I interaction).

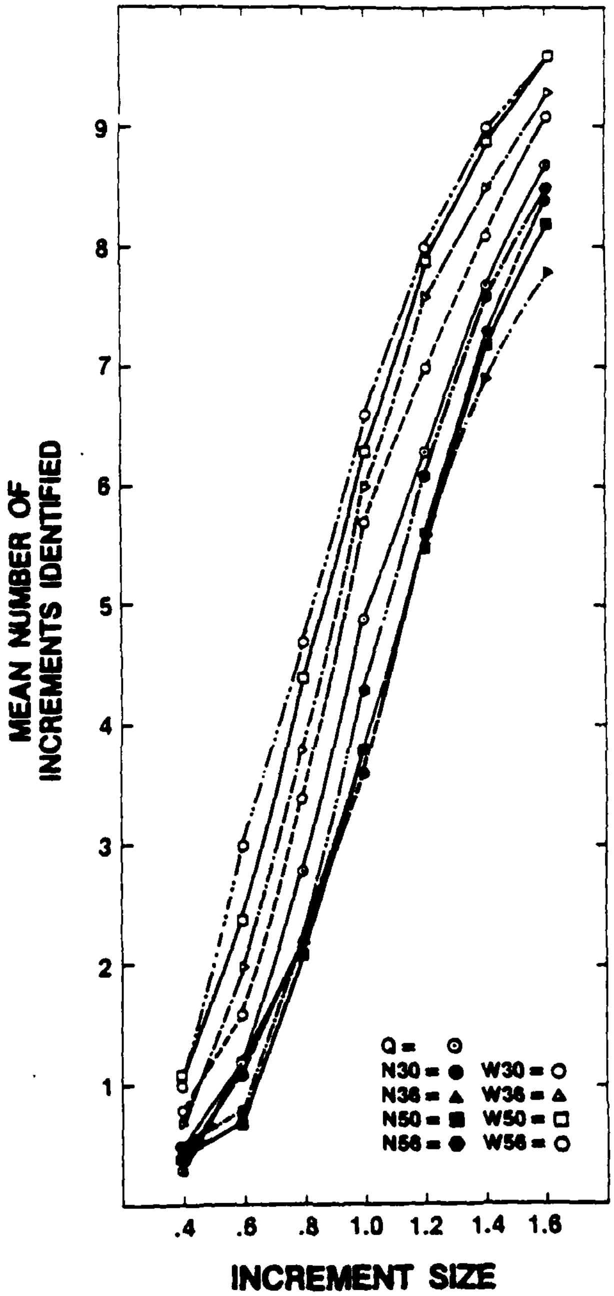

Figure 2. Means of the increments identified for each masking condition, collapsed over test days, reported by masking condition.

Follow-up Contrasts

Table 6 lists all possible contrasts for the nine contralateral masking conditions collapsed over increment size and test day. Inspection of Table 6 reveals that all narrow band masking conditions, regardless of overall SPL level, were not significantly (p>.05) different from one another. Also, all narrow band masking conditions were either not significantly different (p>.05) from the quiet test condition or significantly smaller (p<.05) than the quiet test condition. Further, all wide band masking conditions were significantly larger (p<.05) than the quiet test condition.

Appendix D lists all possible contrasts for the means associated with the seven increment sizes collapsed across all of the contralateral masking conditions and test days. Every increment contrast was significantly different (p<.05) from one another.

WSD Follow-up

Appendix C lists the WSD follow-up conducted using the Satterthwaite degrees of freedom and adjusted mean square error term required for significant interactions of increment size at all levels of masking. All contrasts were significant (p<.05) except those for the extreme increment sizes (.4, .6 and 1.4, 1.6 dB) of certain contralateral masking conditions.

Appendix C lists the WSD results for a significant interaction of contralateral masking at all levels of increment size. This appendix reveals that at the .4-dB increment size, no masking condition differed significantly (p>.05) from any other masking condition. This created the significant two-way interaction reported earlier (Table 5).

DISCUSSION

Introduction

The three experimental conditions investigated in this study are the effect days, contralateral masking, and increment size. A modified DLI task was employed to determine the number of increments a subject could detect. Specifically, subjects were asked to identify the presence of 10 intensity increments, originating from a continuous 4000-Hz background tone, using nine contralateral masking conditions and seven increment sizes. All of the subjects received every condition on 2 test days. The following experimental questions were evaluated:

1. Does the presence of contralateral masking influence a subject's ability to detect small changes in intensity?

2. Is a subject's ability to detect small changes in intensity affected from one test day to another test day?

Table 6

All Possible Mean Contrasts of the Increments Identified for Masking Conditions Collapsed Over Increment Size and Test Day (No. of Obs. - 504)

Subject number	Contrast	Difference	Obtained T statistic	DF value	Critical value of T	Lower limit	Upper limit	Significance
1	Q-N30	0.4583	2.942	35	3.30	-0.0559	0.9726	
2	Q-N36	0.6111	3.422	35	3.30	0.0215	1.2007	a
3	W30-Q	0.5417	3.498	35	3.30	0.0304	1.0529	a
4	W36-Q	0.8413	7.697	35	3.30	0.4805	1.2021	a
5	Q-N50	0.5675	3.353	35	3.30	0.0088	1.1262	a
6	Q-N56	0.2024	1.322	35	3.30	-0.3031	0.7079	
7	W50-Q	1.2202	10.335	35	3.30	0.8305	1.6100	a
8	W56-Q	1.4286	9.720	35	3.30	0.9434	1.9137	a
9	N30-N36	0.1528	1.025	35	3.30	-0.3394	0.6450	
10	W30-N30	1.0000	5.677	35	3.30	0.4185	1.5815	a
11	W36-N30	1.2996	7.887	35	3.30	0.7556	1.8436	a
12	N30-N50	0.1091	0.570	35	3.30	-0.5225	0.7408	
13	N56-N30	0.2560	1.297	35	3.30	-0.3957	0.9076	
14	W50-N30	1.6786	9.829	35	3.30	1.1148	2.2424	a
15	W56-N30	1.8869	8.708	35	3.30	1.1716	2.6022	a
16	W30-N36	1.1528	6.555	35	3.30	0.5722	1.7333	a
17	W36-N36	1.4524	9.558	35	3.30	0.9508	1.9540	a
18	N50-N36	0.0437	0.257	35	3.30	-0.5167	0.6040	
19	N56-N36	0.4087	2.002	35	3.30	-0.2651	1.0826	
20	W50-N36	1.8313	9.549	35	3.30	1.1982	2.4645	a
21	W56-N36	2.0397	9.348	35	3.30	1.3194	2.7600	a
22	W36-W30	0.2996	2.268	35	3.30	-0.1365	0.7357	
23	W30-N50	1.1091	5.806	35	3.30	0.4785	1.7397	a
24	W30-N56	0.7440	4.821	35	3.30	0.2345	1.2535	a
25	W50-W30	0.6786	4.127	35	3.30	0.1358	1.2213	a
26	W56-W30	0.8869	5.480	35	3.30	0.3527	1.4212	a
27	W36-N50	1.4087	7.897	35	3.30	0.8198	1.9976	a
28	W36-N56	1.0437	6.444	35	3.30	0.5090	1.5783	a
29	W50-W36	0.3790	2.749	35	3.30	-0.0761	0.8341	
30	W56-W36	0.5873	4.349	35	3.30	0.1415	1.0331	a
31	N56-N50	0.3651	1.954	35	3.30	-0.2516	0.9817	
32	W50-N50	1.7877	11.183	35	3.30	1.2600	2.3154	a
33	W56-N50	1.9960	11.311	35	3.30	1.4135	2.5786	a
34	W50-N56	1.4226	9.570	35	3.30	0.9319	1.9133	a
35	W56-N56	1.6310	10.998	35	3.30	1.1414	2.1205	a
36	W56-W50	0.2083	1.606	35	3.30	-0.2199	0.6366	

[a]Indicates significance greater than an .05 level.

3. Is a subject's ability to detect small changes in intensity affected when the bandwidth of the contralateral masker is held constant and the SPL of the masker is varied?

4. Is a subject's ability to detect small changes in intensity affected when the overall SPL of the masker is held constant and the bandwidth of the contralateral masker is varied?

5. Is a subject's ability to detect small changes in intensity affected when both the overall SPL and bandwidth of the contralateral masker are varied?

6. Does the presence of contralateral masking at lower levels (30 and 36 dB SPL) have the same influence on a subject's ability to detect small changes in intensity as contralateral masking presented at higher levels (50 and 56 dB SPL)?

Descriptive Statistics and Analysis of Variance

The ability of any experiment to produce reliable results rests upon certain statistical assumptions. In the present experiment, the three most important assumptions were handled in the following manner. First, all subjects were randomly selected from the Pennsylvania State University population of those students meeting the preselection criteria. Second, although the chi-square three-test indicated a violation of the assumption of circularity, a correction factor was calculated using $\hat{\lambda}$ values to correct the degrees of freedom used in establishing the probability of the mean square ratios. Third, the assumption that the sampling distributions of means were normally distributed was accounted for by the large number of observations on which the means were based. The central limit theorem states that with many observations per treatment mean, these means will be normally distributed. The present experiment had 36 subjects per treatment.

Since the experimental design accounted for possible violations, the resulting differences and F values ere judged to be reliable and representative of the population studied. Further analysis of these differences by analysis of variance (Table 5) detected no meaningful interactions. This would indicate that the effects of the experiment varied as a direct result of the main conditions involved. Two of the three conditions (contralateral masking and increment size) were significant ($p<.05$). Test day was not significant ($p>.05$). Thus, it may be concluded with a confidence greater than .95 that the number of increments detected per masking condition varied as a function of that masking condition. It may also be concluded with a confidence greater than .95 that the scores obtained per increment size varied as a function of the increment size measured. Finally, it may be concluded that the number of increments detected was not significantly different on Day 1 compared to Day 2.

Discussion of Experimental Questions

The first experimental question asked if contralateral masking affected the ability of a subject to detect small intensity increases. Table 7 and

Figures 3 and 4 demonstrate that when the contralateral masker had a bandwidth which was smaller in frequency range than the critical band at 4000 Hz, it produced scores consistently smaller than scores obtained in quiet. When the contralateral masker exceeded the critical bandwidth of 4000 Hz, however, all scores obtained were significantly larger ($p<.05$) than the scores obtained in quiet.

The second experimental question asked if a subject's ability to detect small changes in intensity varied from day to day of the experiment. A subject's ability to detect small intensity increments did not differ significantly ($p>.05$) over the 2 test days (Table 5).

Table 7

Quiet Versus All Possible Masking Conditions Mean Contrasts of the Increments Identified for Masking Condition Collapsed Over Increment Size and Test Day

Paired Contrast	Difference	Obtained T	Critical value of T	Significance
Q-N30	0.25600	1.297	3.30	
Q-N36	0.61100	3.422	3.30	a
Q-W30	0.54170	3.498	3.30	b
Q-W36	0.84130	7.697	3.30	b
Q-N50	0.56750	3.353	3.30	a
Q-N56	0.02024	1.322	3.30	
Q-W50	1.22020	10.335	3.30	b
Q-W56	1.42860	9.720	3.30	b

[a]Indicates value which demonstrated greater than an .05 level.
[b]Indicates values which were more than an .05 level of significance greater than quiet condition.

In answer to the third experimental question, a subject's ability to detect small intensity changes was affected selectively when the bandwidth of the contralateral masker was held constant and the overall SPL of the contralateral masker was varied. Tables 8 and 9 provide a summary of how the results from the narrow and wide band (277 and 926 Hz) contralateral maskers compare to themselves. Table 8 contrasts all narrow band masking conditions. It can be seen from this table that the narrow band masking condition did not differ significantly ($p>.05$) from any other narrow band masking condition. It should be remembered that the frequency range of the narrow bandwidth contralateral masker was well within the critical band of the 4000-Hz test frequency. Regardless of the overall SPL (30, 36, 50, 56 dB), as long as the bandwidth remained subcritical, no influence was exerted on the ability to detect small changes in intensity. Table 9 contrasts all wide band contralateral masking of varying SPL. The wide band maskers had a frequency

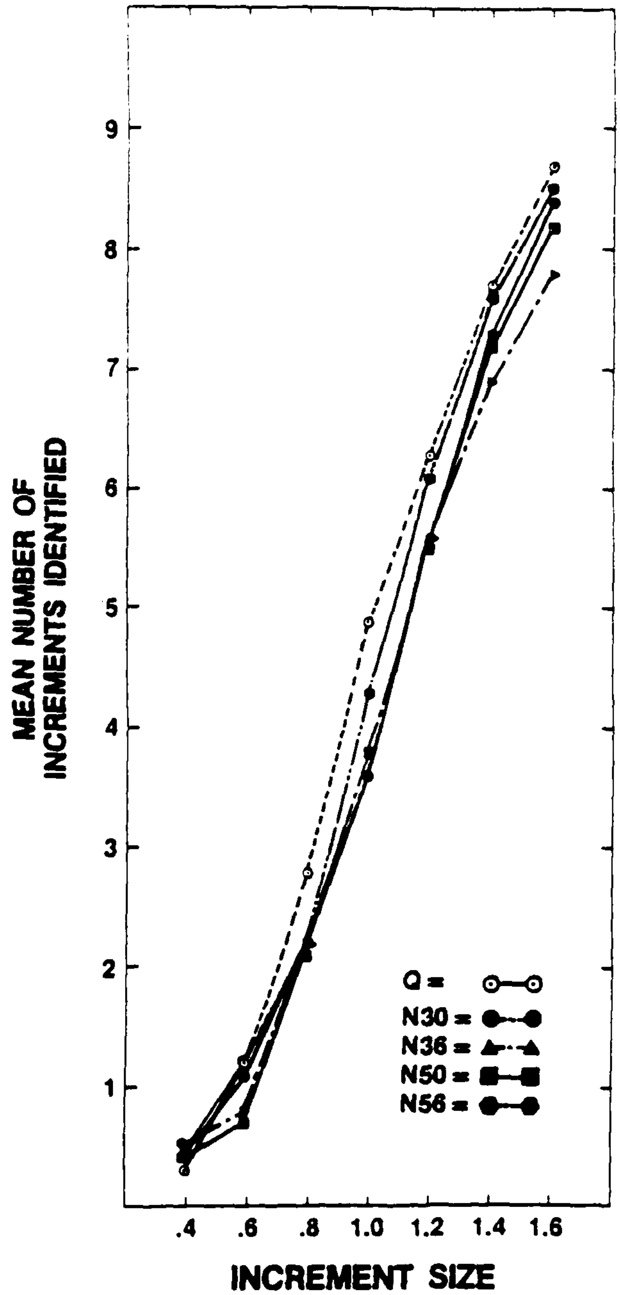

Figure 3. Mean scores of the increments identified for quiet and all narrow band masking conditions, collapsed over test days, reported by increment size.

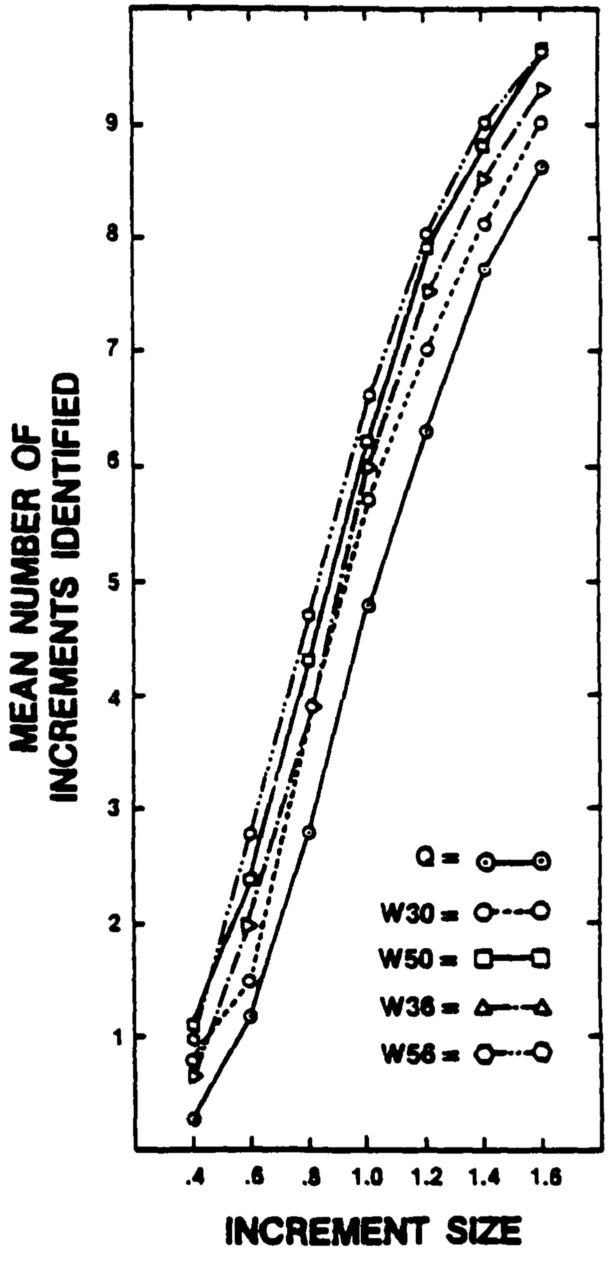

Figure 4. Mean scores of the increments identified for quiet and all wide band masking conditions, collapsed over test days, reported by increment size.

range that was wider than the critical band for the 4000-Hz test frequency. The results of these contrasts indicated that supracritical masking in the contralateral ear provided the test ear with information which was bandwidth- and intensity-critical.

Table 8

All Possible Narrow Band Mean Contrasts of the Increments Identified for Masking Condition Collapsed Over Increment Size and Test Day

Paired contrast	Difference	Obtained T	Critical value of T	Significance
N30-N36	0.1528	1.025	3.30	a
N30-N50	0.1091	0.570	3.30	
N30-N56	0.2560	1.297	3.30	
N36-N50	0.0437	0.257	3.30	
N36-N56	0.4807	2.002	3.30	
N50-N56	0.3651	1.954	3.30	

[a]All contrasts were insignificant at the .05 level.

Table 9

All Possible Wide Band Mean Contrasts of the Increments Identified for Masking Condition Collapsed Over Increment Size and Test Day

Paired contrast	Difference	Obtained T	Critical value of T	Significance
W30-W36	0.2996	2.268	3.30	
W30-W50	0.6786	4.127	3.30	a
W30-W56	0.8869	5.480	3.30	a
W36-W50	0.3790	2.749	3.30	
W36-W56	0.5873	4.349	3.30	a
W50-W56	0.2083	1.606	3.30	

[a]Indicates contrasts that are significant at the .05 level.

Table 9 indicates that the wide band contrasts that differed by less than 20 dB were not significantly different ($p > .05$) from each other. The three wide band contrasts that were 20 dB or more apart were significantly different

($p<.05$) in their ability to influence the detection of small intensity increments. Figures 5 and 6 also demonstrate that for the low level contrasts (30 and 36 dB SPL) when bandwidth was held constant and the overall SPL varied, the subject's ability to discriminate did not change significantly.

The fourth experimental question asked if a subject's ability to detect small changes in intensity was affected when the overall SPL of the masker was held constant and the bandwidth of the contralateral masker was varied. All the resulting contrasts were significant ($p<.05$). Table 10 and Figures 7 and 8 display this fact for selected low level contrasts (30 and 36 dB SPL).

The fifth experimental question asked if the ability of subjects to detect small increases in intensity was affected when both the overall SPL and contralateral masking were varied. The subjects demonstrated a significant difference ($p<.05$) in their ability to detect small changes in intensity (Table 10 and Figures 9 and 10). This finding was not surprising in the case of Figure 9 which compared a narrow bandwidth masker of 30 dB SPL with the results of a wide bandwidth masker of 36 dB SPL. The findings in Figure 10 were more important. This contrast demonstrated that if both SPL and bandwidth were varied to create equal energy per cycle for both contralateral masking conditions (N36 versus W30), there was still a significant difference, with the wider lower SPL masker resulting in the higher scores.

Table 10

Narrow Versus Wide Band Mean Contrasts at 30 and 36 dB SPL of the Increment Identified for Masking Condition Collapsed Over Increment Size and Test Day

Paired contrast	Difference	Obtained T	Critical value of T	Significance
N30-N36	0.1528	1.025	3.30	
W30-W36	0.2996	2.268	3.30	
N30-W30	1.0000	5.677	3.30	a
N36-W36	1.4524	9.558	3.30	a
N30-W36	1.2996	7.887	3.30	a
N36-W30	1.1528	6.555	3.30	a

[a]Contrasts are significant at the .05 level.

The sixth experimental question determined that the presence of contralateral masking at both SPLs (30/36 and 50/56 dB) had identical effects on a subject's ability to detect small changes in intensity. Table 11 presents a summary of selected contralateral masking conditions that were paired in an identical order to the contrasts listed in Table 10. The

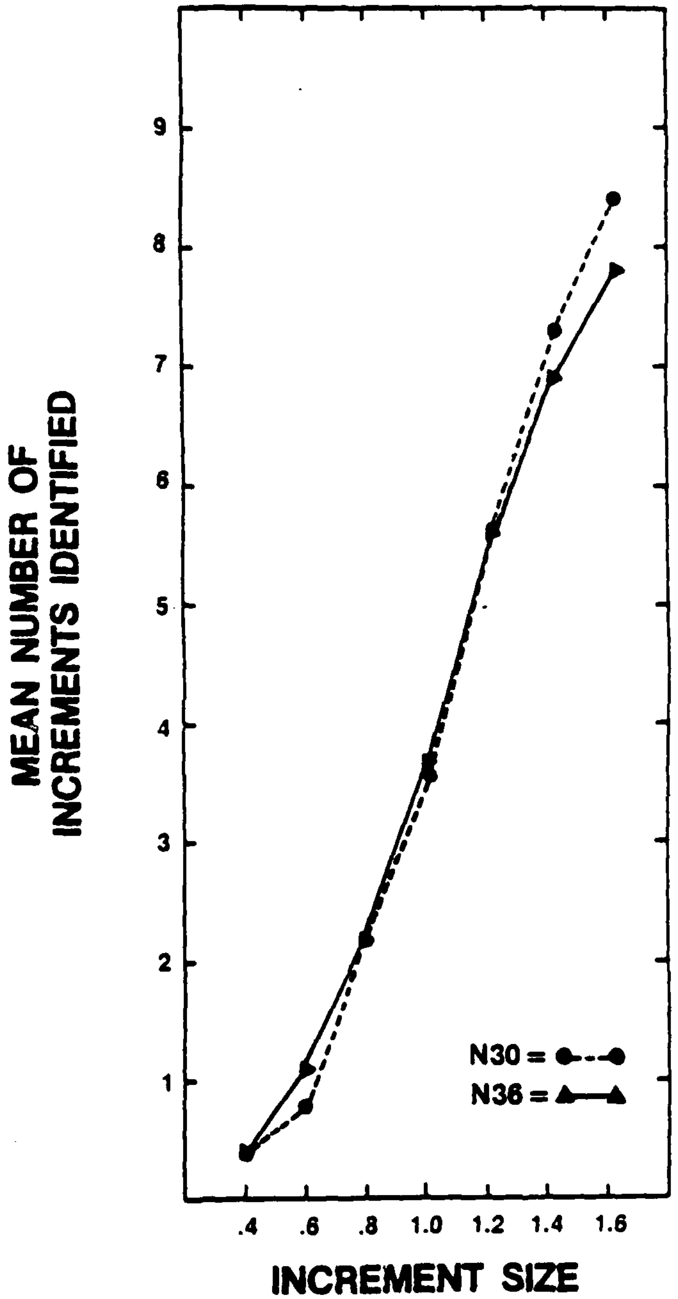

Figure 5. Mean scores of the increments identified for the N36 and N30 masking conditions, collapsed over test days, reported by increment size.

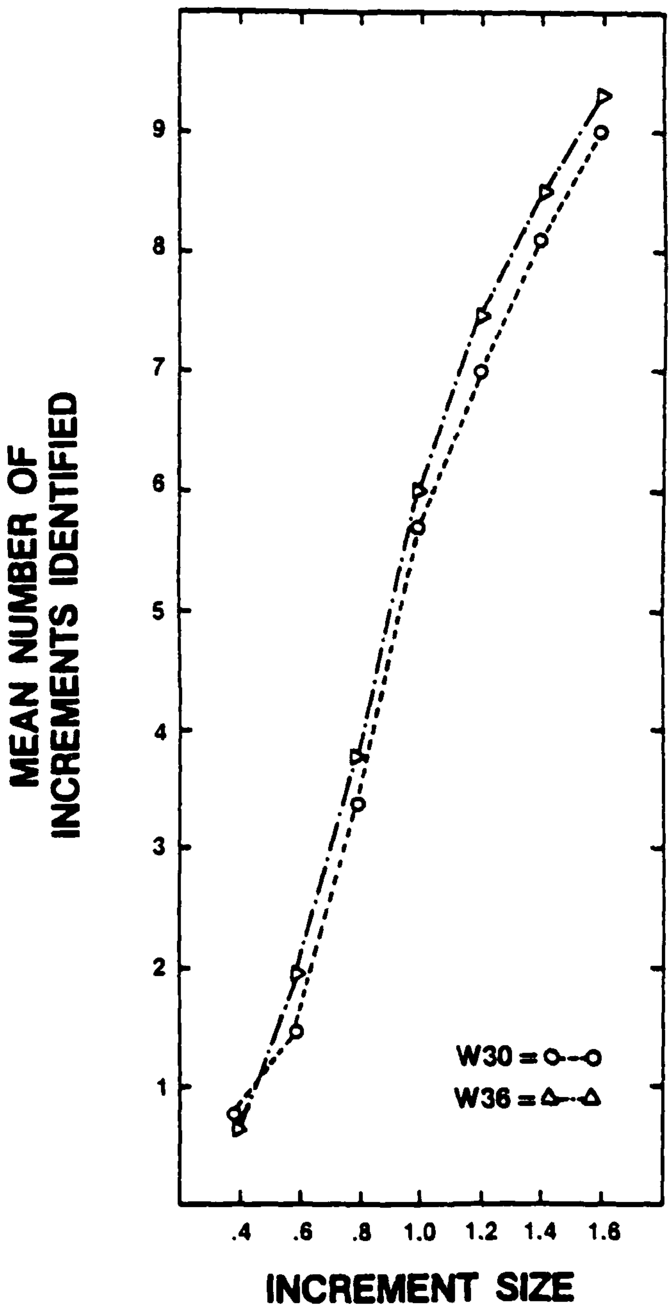

Figure 6. Mean scores of the increments identified for the W30 and W36 masking conditions, collapsed over test days, reported by increment size.

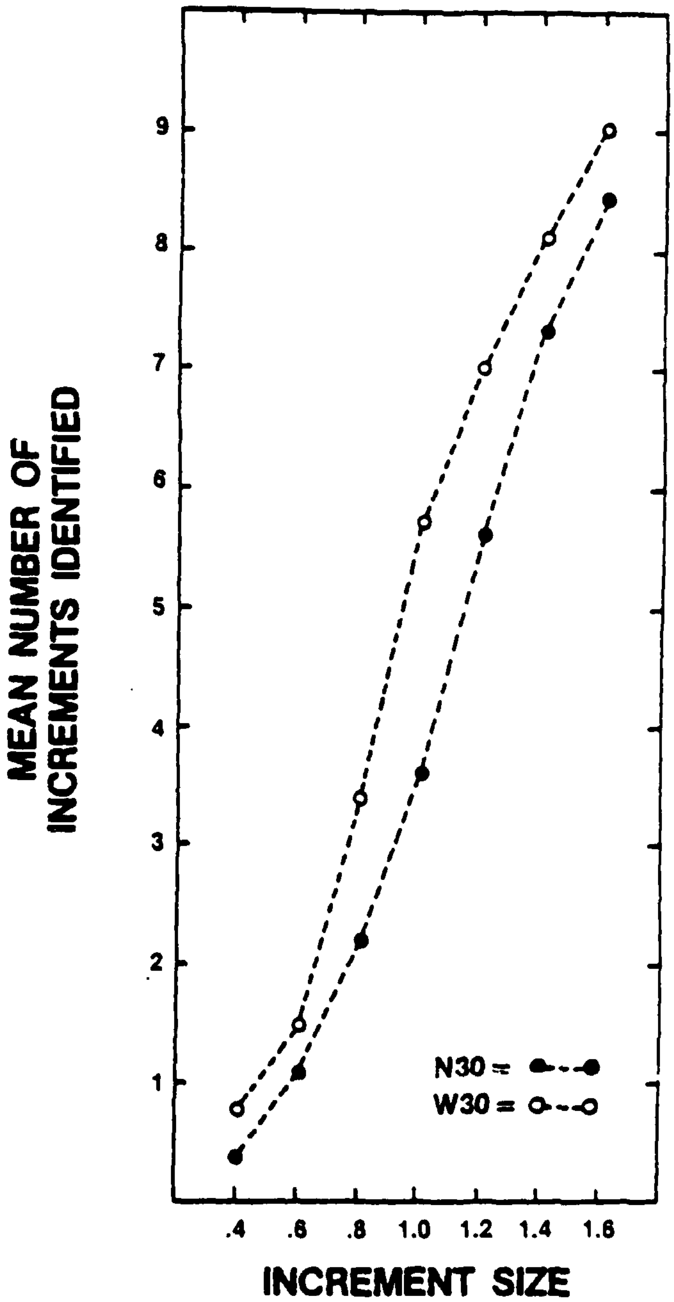

Figure 7. Mean scores of the increments identified for the N30 and W30 masking conditions, collapsed over test days, reported by increment size.

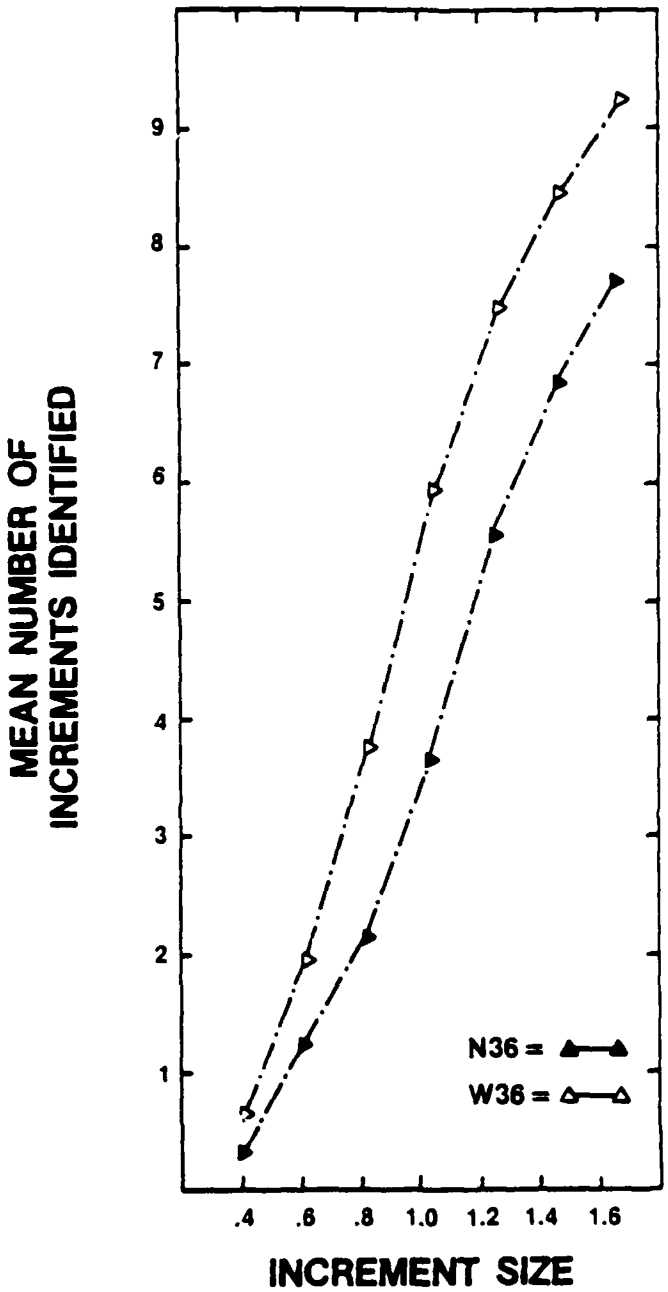

Figure 8. Mean scores of the increments identified for the N36 and W36 masking conditions, collapsed over test days, reported by increment size.

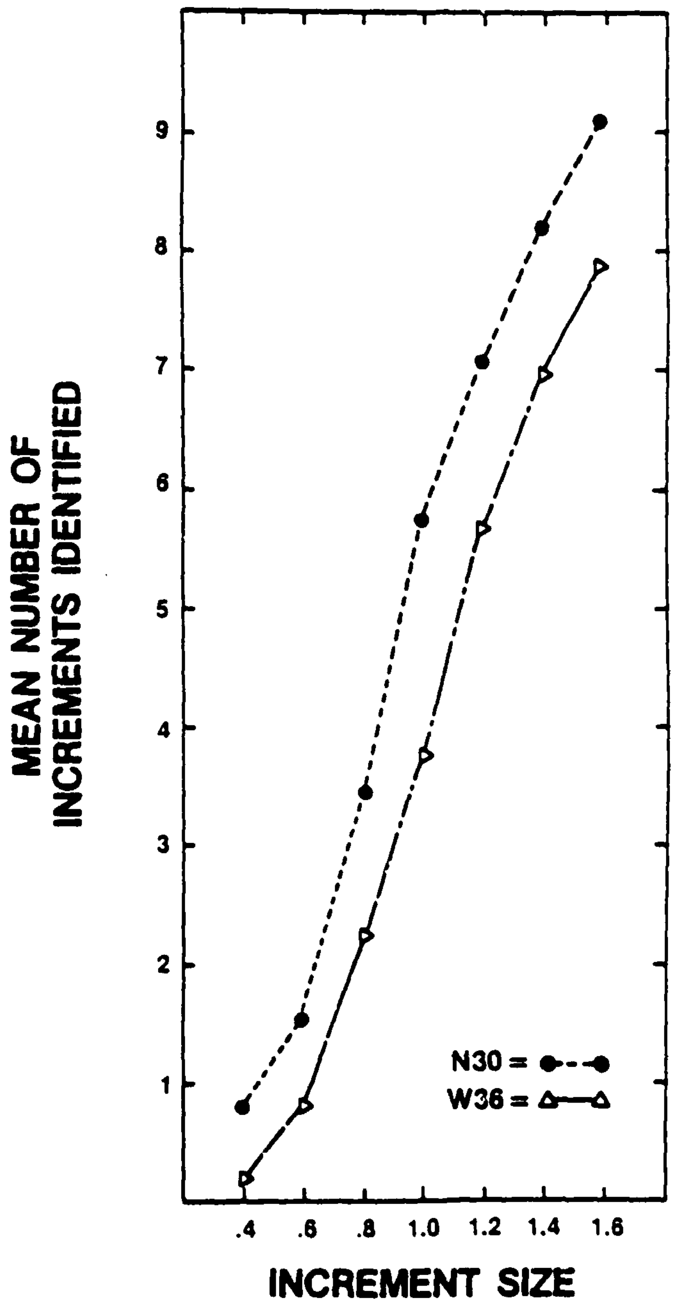

Figure 9. Mean scores of the increments identified for the N30 and W36 masking conditions, collapsed over test days, reported by increment size.

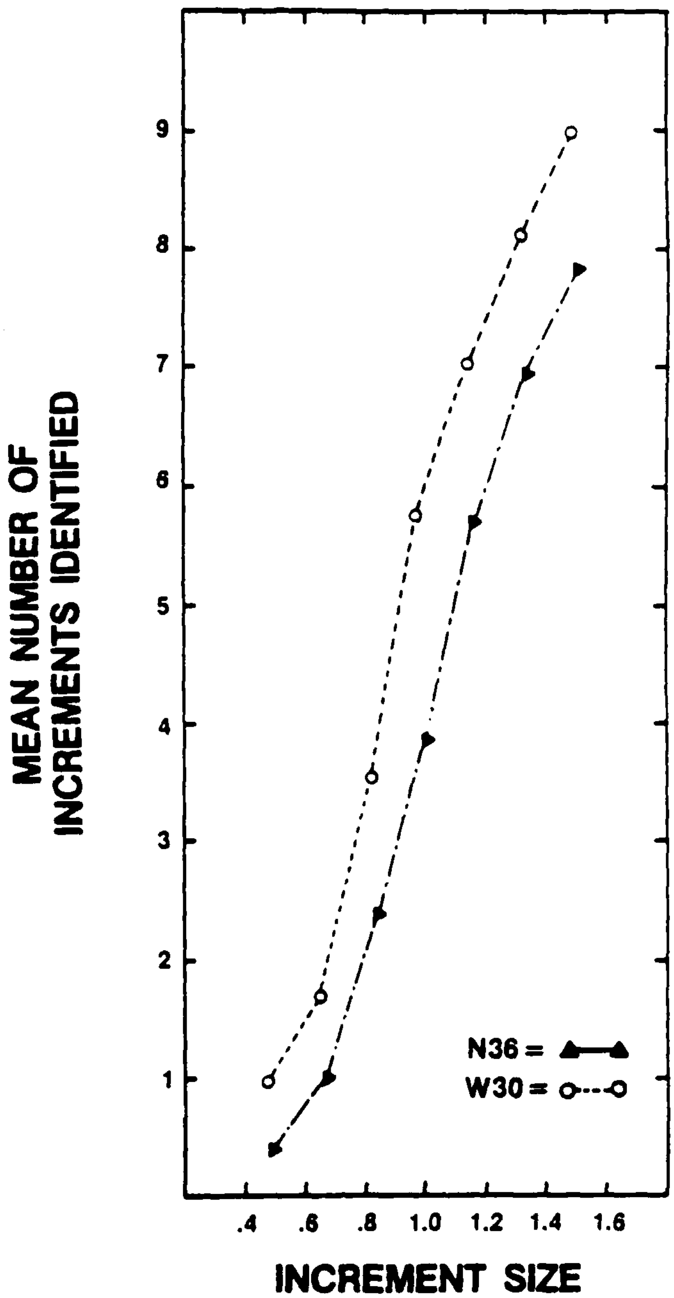

Figure 10. Mean scores of the increments identified for the N36 and W30 masking conditions, collapsed over test days, reported by increment size.

contrasts in Table 11 used overall SPL of 50 and 56 dB. Figures 11 through 16 replicate the lower level (30 and 36 dB SPL) findings:

1. The presence of contralateral masking influenced a subject's ability to detect small changes in intensity.

2. The subject's ability did not change over test days.

3. Detection differences from equal bandwidths of unequal overall SPL were not significant.

4. Different bandwidth contralateral masking conditions of equal overall SPL were significantly different, with the wider bandwidths producing significantly more detections.

5. When both the overall SPL and bandwidths were different, a significant difference was noted between the contrasts, even when these differences resulted in the energy per cycle being equal.

Therefore, it may be concluded with a confidence greater the .95 that the contralateral masking effect produces similar patterns of response over a modest SPL range.

The preceding group of contrasts has answered all of the questions posed by the experimental design. All test conditions indicate that the central nervous system is bandwidth sensitive. Within the scope of the experiment, only the upper level (50 and 56 dB SPL) wide band contralateral maskers were influenced by intensity (Table 9).

Table 11

Narrow Versus Wide Band Mean Contrasts at 50 and 56 dB SPL of the Increment Identified for Masking Condition Collapsed Over Increment Size and Test Day

Paired contrast	Difference	Obtained T	Critical value of T	Significance
N50-N56	.3651	1.954	3.30	
W50-W56	.2083	1.606	3.30	
N50-W50	1.7877	11.183	3.30	a
N56-W56	1.6310	10.998	3.30	a
N50-W56	1.9960	11.311	3.30	a
N56-W50	1.4226	9.570	3.30	a

[a]Contrasts are significant at the .05 level.

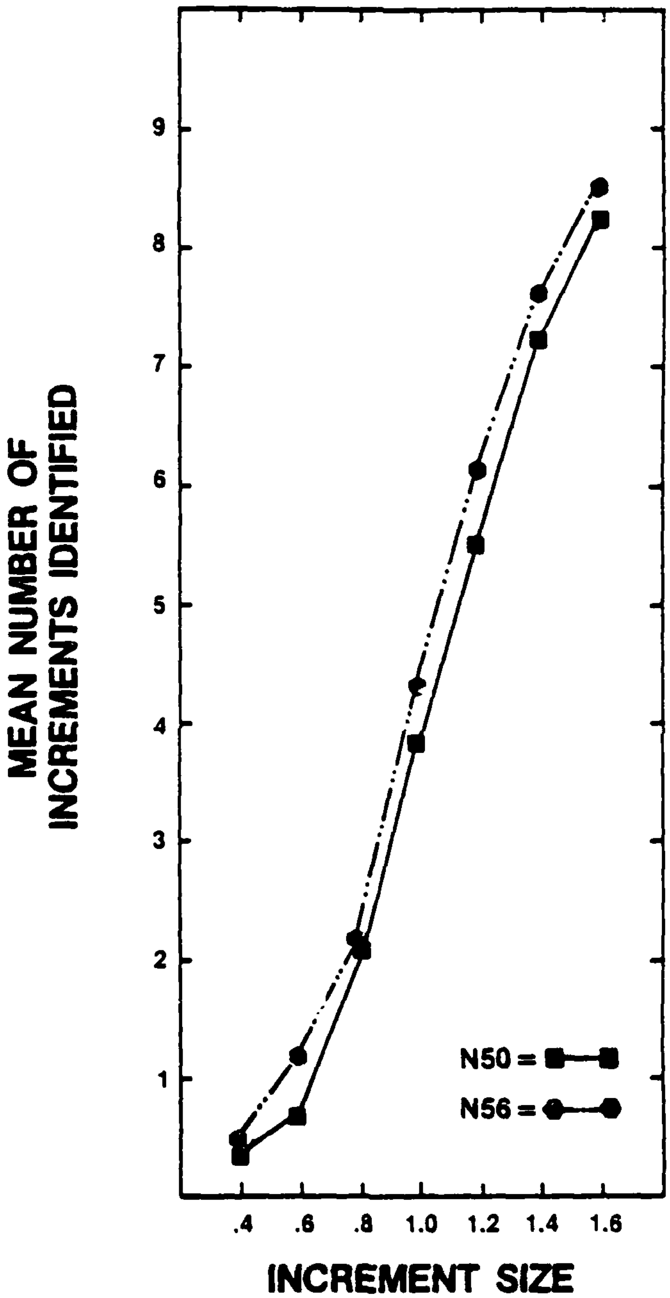

Figure 11. Mean scores of the increments identified for the N50 and N56 masking conditions, collapsed over test days, reported by increment size.

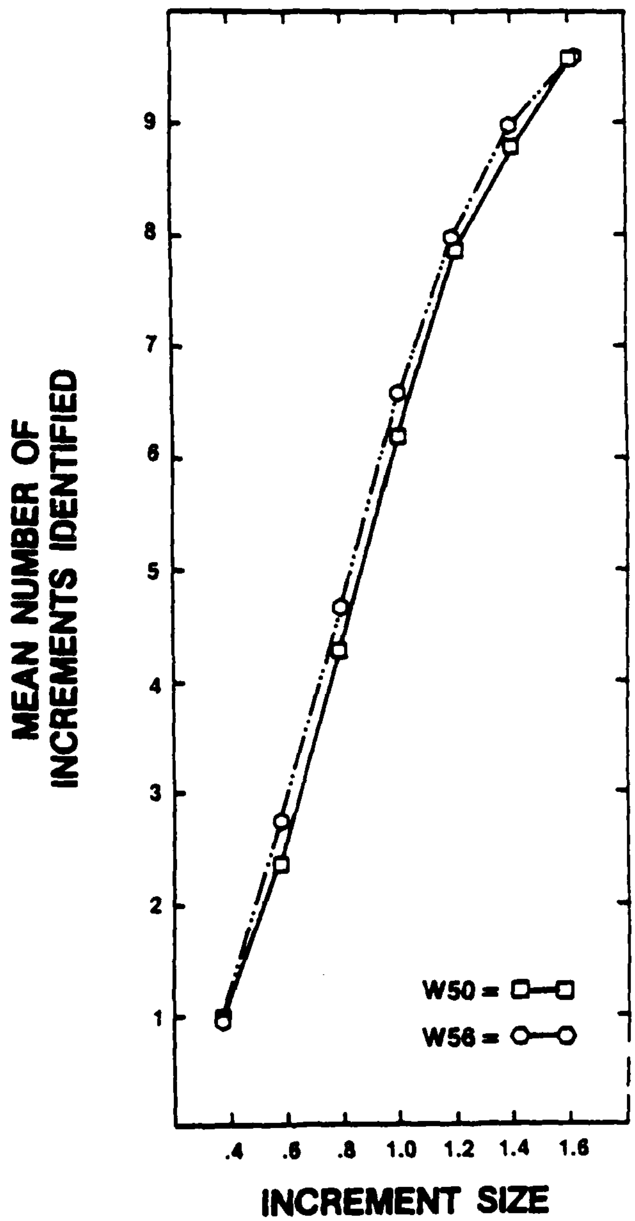

Figure 12. Mean scores of the increments identified for the W50 and W56 masking conditions, collapsed over test days, reported by increment size.

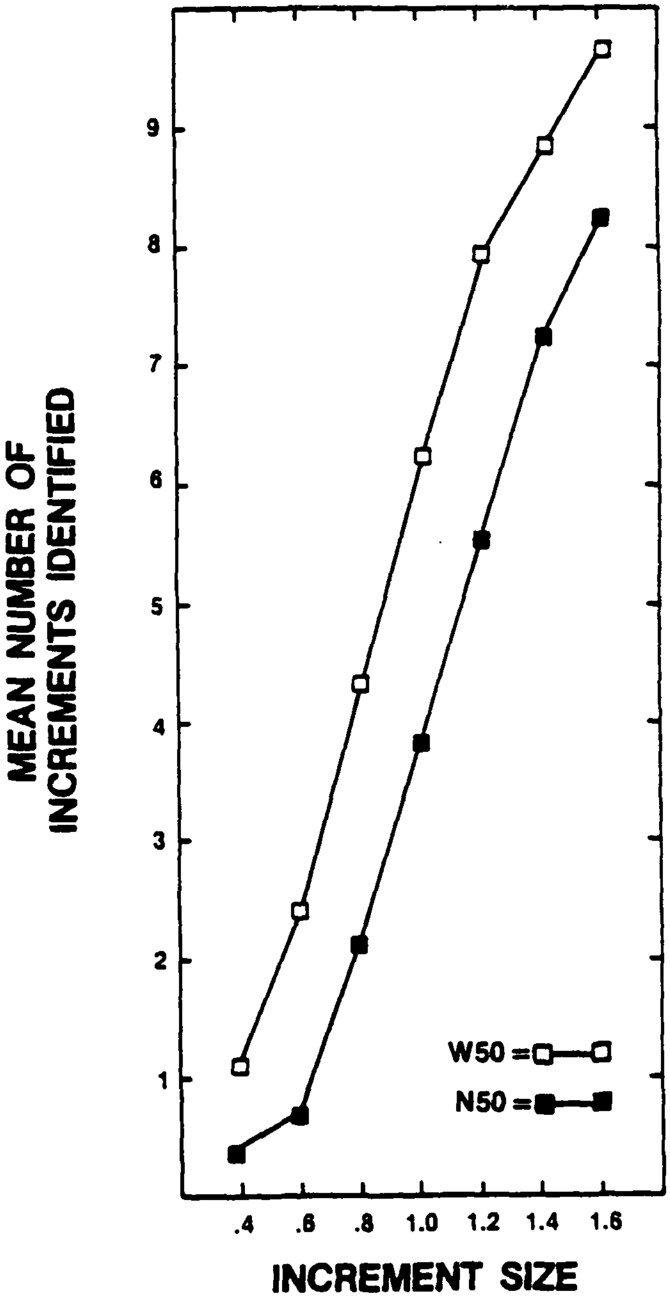

Figure 13. Mean scores of the increments identified for the N50 and W50 masking conditions, collapsed over test days, reported by increment size.

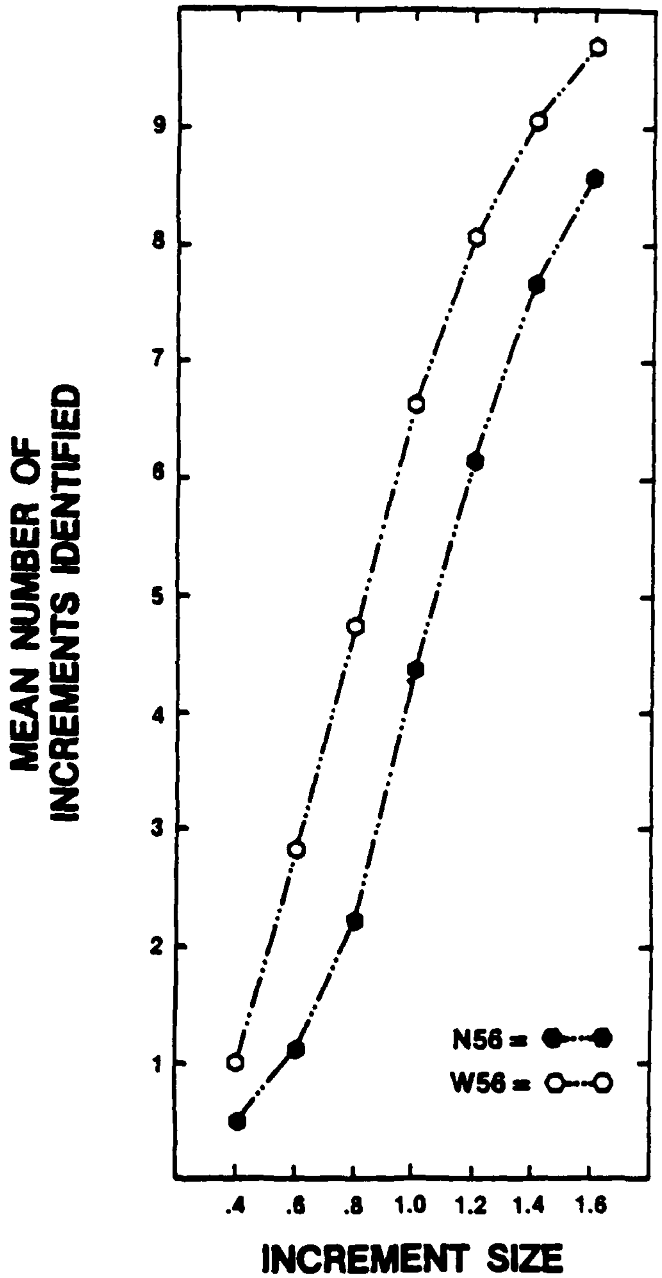

Figure 14. Mean scores of the increments identified for the N56 and W56 masking conditions, collapsed over test days, reported by increment size.

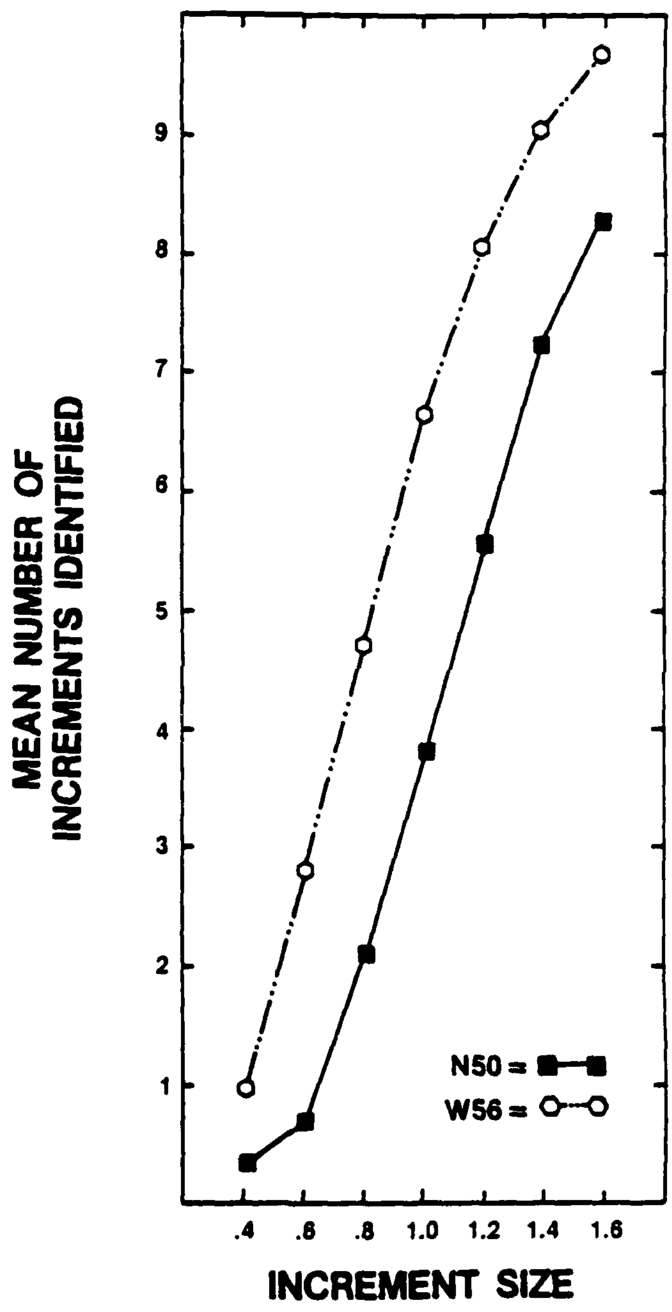

Figure 15. Mean scores of the increments identified for the N50 and W56 masking conditions, collapsed over test days, reported by increment size.

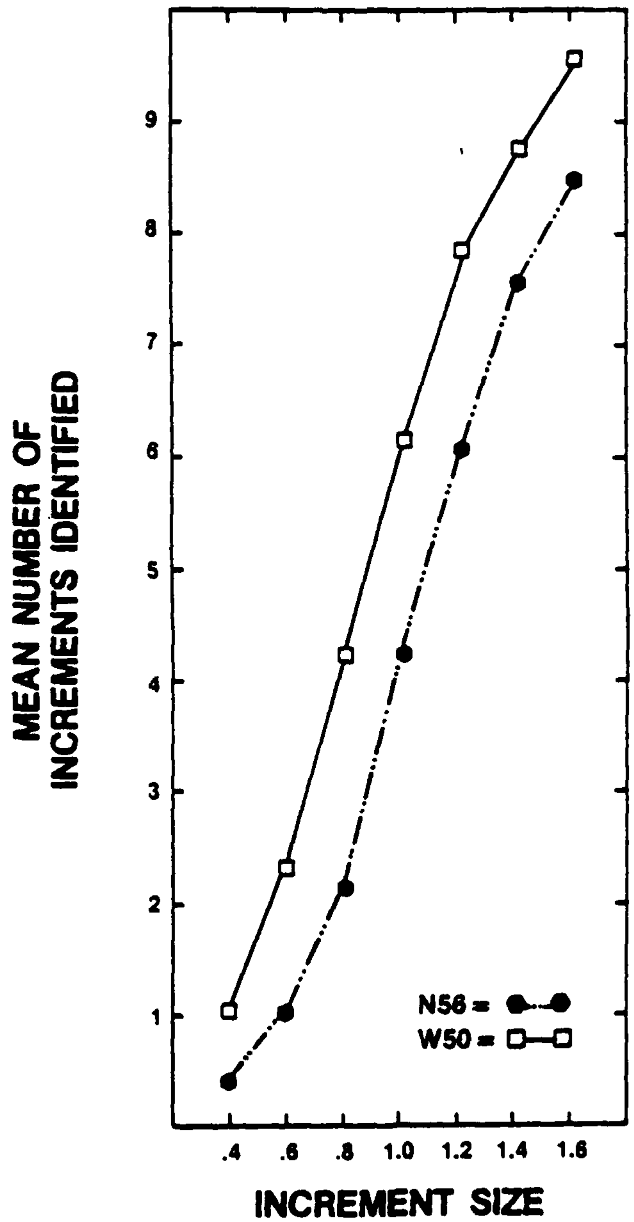

Figure 16. Mean scores of the increments identified for the N56 and W50 masking conditions, collapsed over test days, reported by increment size.

Contralateral Masking and Critical Bands

Anthony, Michael, and Mitchell (1974) reported:

> The critical band may be defined as some frequency bandwidth beyond which a listener's subjective response will change. The loudness sensation produced by any random noise with a bandwidth less than that of the critical band will appear to be the same if sound pressure level is held constant. However, as bandwidth is increased beyond that of the critical band, for the same sound pressure level, the loudness sensation increases. (p. 2)

Further, Anthony et al. (1974) reported that noise-induced hearing loss results in a widening of the critical bands and produces increased sensitivity to small changes in loudness (intensity).

In the present study, a contralateral masking stimulus produced the same effect. That is, contralateral masking presented to a normal ear, wider than a critical band, resulted in an increased sensitivity to hearing small increments in intensity. This increased sensitivity for small intensity differences is similar to that for an ear that has suffered a noise-induced trauma. In both situations, an increased ability to detect small intensity differences occurs. It has been hypothesized that this increased sensitivity in the ear because of noise trauma occurs as a result of the widened critical bands. This leads to the hypothesis that supracritical band contralateral masking produces a similar widening of the critical band phenomena in normal ears. This change in sensitivity must have occurred beyond the cochlea because the level of the contralateral masking was never loud enough to cross over to the test ear. Thus, a central component is suspected, perhaps at the superior olivary complex or as high as the auditory cortex. Thus, the findings from this study support theories of a central neural shaping for intensity discrimination (Morest, Ard, & Yurgelun-Todd, 1979; Salvi, Perry, Hamernik, & Henderson, 1982; Webster & Webster, 1978).

Practical Implications

Since it is possible to influence the detection of small intensity increments with contralateral masking, it might be possible to classify people according to their ability to hear these intensity increments when presented with contralateral masking. As an example, a person with normal bands, but with undetected cochlear damage, might exhibit a significant difference under contralateral masking, in his or her ability to detect small intensity increments. A person who still possesses normal hearing sensitivity but has a widened critical band due to noise trauma, may not show a change, under contralateral masking, in his or her ability to detect small intensity increments. Thus, if widened critical bands precede permanent auditory threshold shifts because of noise trauma, it might be possible to identify people who are preparing to demonstrate an elevation in peripheral hearing threshold. These people would exhibit a high overall score (number of increments identified) and minimal change in their scores when the quiet results were compared with wide band contralateral masking results. Conversely, people who exhibited low scores and minimal shifts between test conditions would be identified as those least likely to incur a noise-induced hearing shift.

Research Implication

The research implication concerns the frequency at which the difference limen for intensity was evaluated. The results of several experiments (Blegvad & Terildsen, 1967; Shimizu, 1968) reported larger DL scores at the higher frequencies. No attempt has been made to match the contralateral masking frequency to the test tone as was done in this study, however. The present findings indicated that detection of small intensity increments was related to the width of the critical band. Thus, further research should be completed to detail the results at other test frequencies using contralateral maskers which would be narrower and wider than the critical bands of the test frequencies being investigated.

CONCLUSIONS

The purpose of this study was to investigate the effect of narrow and wide band contralateral masking on a subject's ability to identify small increases in intensity.

The three experimental conditions investigated were the effect days, contralateral masking, and increment size. A modified DLI task was employed to determine the number of increments a subject could detect. Specifically, subjects were asked to identify the presence of 10 intensity increments, originating from a continuous 4000-Hz background tone, using nine contralateral masking conditions and seven increment sizes. All of the subjects received every condition on 2 test days. The subjects' scores were analyzed using an Analysis of Variance with Repeated Measures (ANOVR) and appropriate follow-up procedures.

Within the constraints of the experimental design, the data can be summarized as follows:

1. Contralateral masking influenced a subject's ability to identify small increases in intensity.

2. The subjects' responses did not vary significantly over the 2 test days.

3. Regardless of the overall SPL (30, 36, 50, 56 dB), as long as the bandwidth remained subcritical (N), no influence was exerted on the ability to detect small changes in intensity. Supracritical (W) contralateral masking provided a test ear with bandwidth- and intensity-critical information, however. Additionally, all wide band contralateral maskers resulted in an increased ability to detect small intensity increases and all narrow band contralateral maskers resulted in a corresponding decrease when compared to the quiet test conditions.

4. When the overall SPL was held constant and the bandwidth varied, subjects' mean scores were significantly better for the wide band condition.

5. When the overall SPL and bandwidth were both varied, wide band contralateral masking significantly improved a subject's ability to identify small increases in intensity. This also held true for those test conditions of equal level per cycle energy.

6. The effect of contralateral masking on the ability to identify small increases in intensity produced similar response patterns over the SPL range evaluated in the experiment.

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APPENDIX A

INSTRUCTIONS

INSTRUCTIONS

In this study, we are trying to measure your ability to detect small increases in the intensity of a pure tone stimulus. These small increases will be added to a continuous tone and will seem to create a swelling of the tone.

The tones will be presented to your right ear. We are interested in comparing your ability to detect these increases in quiet with your detection ability when a continuous noise is presented simultaneously to the opposite ear.

Each time you hear an intensity increase, press the hand switch. We will begin with a practice run to give you an idea of what these intensity changes sound like. At the beginning of each run, you will hear two or three practice increments and then you will be told that the run is starting.

Remember: press the hand switch when you think you hear an increase in intensity.

APPENDIX B

RAW DATA

KEY:

Q = quiet test condition, no masking
N30 = narrow band masking at 30 dB SPL, 277 Hz
N36 = narrow band masking at 36 dB SPL, 277 Hz
N50 = narrow band masking at 50 dB SPL, 277 Hz
N56 = narrow band masking at 56 dB SPL, 277 Hz
W30 = wide band masking at 30 dB SPL, 926 Hz
W36 = wide band masking at 36 dB SPL, 926 Hz
W50 = wide band masking at 50 dB SPL, 926 Hz
W56 = wide band masking at 56 dB SPL, 926 Hz

Raw Data

Subject	Day	Age	Masking	Order	1.6	1.4	1.2	1.0	.8	.6	.4
					Increment Size in dB						
1	1	23-4	Q	1	10	9	5	7	2	1	0
			N30	2	10	10	8	9	5	1	0
			N36	3	10	10	8	8	8	4	5
			W30	4	10	10	7	7	4	0	0
			W36	5	10	10	10	8	3	0	1
			N50	6	10	10	10	8	6	2	1
			N56	7	9	10	7	2	0	0	0
			W50	8	10	10	10	9	10	4	4
			W56	9	10	10	8	5	3	3	1
	2		W56	1	10	10	10	9	7	4	1
			W50	2	10	10	10	8	9	4	2
			N56	3	10	10	10	6	2	3	1
			N50	4	10	10	10	10	9	2	1
			W36	5	10	10	10	8	7	6	4
			W30	6	10	10	9	8	10	5	0
			N36	7	10	10	10	10	9	2	2
			N30	8	10	10	10	8	6	4	0
			Q	9	10	9	10	10	9	5	1
2	1	22-7	N30	1	10	10	10	10	3	1	1
			N36	2	10	10	10	6	6	1	1
			W30	3	10	10	10	10	6	6	0
			W36	4	10	9	9	8	3	4	0
			N50	5	10	10	10	5	1	0	0
			N56	6	10	10	10	10	7	4	0
			W50	7	10	10	10	10	8	5	0
			W56	8	10	10	10	10	7	6	0
			Q	9	9	10	9	6	7	1	0
	2		W50	1	10	10	10	7	6	4	1
			N56	2	10	8	7	7	5	2	1
			N50	3	10	7	2	7	5	3	0
			W36	4	10	9	10	7	7	5	1
			W30	5	8	9	7	7	5	6	4
			N36	6	10	8	6	5	4	3	2
			N30	7	10	10	6	3	2	0	0
			Q	8	7	6	6	6	5	2	0
			W56	9	10	10	9	8	8	5	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
3	1	23-1	N36	1	5	3	2	0	1	0	0
			W30	2	6	1	1	3	0	1	0
			W36	3	10	5	7	1	2	3	3
			N50	4	8	10	7	5	6	2	0
			N56	5	8	7	6	3	4	2	0
			W50	6	10	10	8	7	5	7	5
			W56	7	9	9	7	5	4	6	3
			Q	8	10	7	7	4	5	5	1
			N30	9	10	7	6	7	4	3	2
	2		N56	1	10	7	8	5	1	4	4
			N50	2	8	8	5	6	3	1	3
			W36	3	10	8	8	4	5	2	0
			W30	4	9	9	4	2	6	2	5
			N36	5	9	7	6	7	3	6	4
			N30	6	10	7	9	4	5	7	3
			Q	7	8	8	8	6	3	4	0
			W56	8	9	7	5	6	6	2	4
			W50	9	9	8	9	8	5	6	6
4	1	23-2	W30	1	10	10	7	4	6	1	0
			W36	2	10	8	10	7	9	4	1
			N50	3	7	8	7	4	0	0	0
			N56	4	10	7	7	8	7	1	0
			W50	5	10	10	10	9	4	2	1
			W56	6	10	10	5	7	7	1	0
			Q	7	9	8	5	5	0	0	1
			N30	8	10	10	8	4	6	0	0
			N36	9	9	10	7	7	5	0	0
	2		N50	1	10	10	10	5	3	2	0
			W36	2	10	10	6	7	3	1	0
			W30	3	10	9	7	6	3	1	0
			N36	4	9	7	4	1	0	0	0
			N30	5	10	9	7	8	1	0	0
			Q	6	9	9	9	7	5	0	0
			W56	7	10	10	8	6	3	1	1
			W50	8	10	10	9	8	8	2	1
			N56	9	9	6	6	0	2	0	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB						
					1.6	1.4	1.2	1.0	.8	.6	.4
5	1	24-3	W36	1	10	9	10	10	4	0	0
			N50	2	10	10	3	1	0	0	0
			N56	3	7	9	8	5	3	3	1
			W50	4	10	10	10	7	6	5	0
			W56	5	10	9	10	7	6	3	1
			Q	6	10	9	10	9	8	4	0
			N30	7	10	10	7	6	3	2	1
			N36	8	10	9	10	8	4	0	0
			W30	9	10	9	10	10	4	0	0
	2		W36	1	9	8	8	9	3	3	1
			W30	2	10	7	7	2	3	0	2
			N36	3	7	4	3	2	0	0	0
			N30	4	10	9	8	3	1	1	0
			Q	5	9	8	6	1	0	0	0
			W56	6	9	7	5	3	2	0	0
			W50	7	8	6	3	4	3	0	0
			N56	8	10	9	8	2	1	0	1
			N50	9	9	6	1	0	0	0	0
6	1	22-7	N50	1	10	9	7	8	4	3	0
			N56	2	10	10	6	8	3	7	3
			W50	3	10	10	9	5	5	3	2
			W56	4	10	10	10	9	7	6	2
			Q	5	9	8	6	5	3	3	0
			N30	6	9	9	10	8	2	3	0
			N36	7	10	10	8	8	6	4	0
			W30	8	10	9	6	7	8	2	3
			W36	9	10	9	9	6	6	5	0
	2		W30	1	10	10	9	10	6	6	5
			N36	2	10	9	10	8	7	2	0
			N30	3	10	7	9	6	8	5	3
			Q	4	7	8	5	7	3	5	2
			W56	5	8	10	10	8	3	5	4
			W50	6	10	8	10	10	9	5	5
			N56	7	10	10	7	8	4	2	1
			N50	8	10	9	8	5	8	3	1
			W36	9	10	10	8	9	8	3	3

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
7	1	23-4	N56	1	7	8	5	5	4	3	4
			W50	2	10	7	5	3	3	4	4
			W56	3	9	5	5	4	3	4	1
			Q	4	6	7	5	5	3	3	0
			N30	5	5	8	4	7	3	3	0
			N36	6	6	8	2	4	5	0	0
			W30	7	10	8	9	7	2	3	2
			W36	8	8	9	9	6	6	2	1
			N50	9	8	8	6	3	3	0	1
	2		N36	1	9	7	5	7	5	4	3
			N30	2	8	8	6	4	8	5	3
			Q	3	7	7	6	5	7	5	0
			W56	4	10	9	7	6	8	1	1
			W50	5	8	7	7	6	2	0	0
			N56	6	8	6	5	5	3	1	1
			N50	7	9	7	5	4	2	3	1
			W36	8	8	9	7	7	5	3	0
			W30	9	9	7	7	6	5	5	0
8	1	20-11	W50	1	10	10	9	7	3	1	0
			W56	2	10	9	10	9	8	2	0
			Q	3	10	8	8	6	5	1	0
			N30	4	10	10	9	5	2	2	0
			N36	5	10	10	7	7	7	4	0
			W30	6	10	10	9	8	5	2	1
			W36	7	10	10	8	8	4	5	0
			N50	8	10	8	8	8	0	3	0
			N56	9	10	9	6	5	0	0	0
	2		N30	1	9	9	7	9	8	4	1
			Q	2	10	10	10	8	7	5	0
			W56	3	10	10	8	5	3	5	0
			W50	4	10	10	10	10	9	4	1
			N56	5	10	9	6	5	5	2	0
			N50	6	10	7	8	7	3	2	0
			W36	7	10	10	10	6	5	5	3
			W30	8	9	8	9	10	7	5	0
			N36	9	10	8	8	6	6	1	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	1.6	1.4	1.2	1.0	.8	.6	.4
					Increment Size in dB						
9	1	23-5	W56	1	10	10	10	9	9	6	0
			Q	2	9	9	10	9	8	4	1
			N30	3	10	8	6	5	3	4	0
			N36	4	9	10	10	6	5	5	3
			W30	5	10	10	9	9	5	5	5
			W36	6	10	10	10	10	6	2	2
			N50	7	10	10	10	9	6	5	5
			N56	8	10	10	9	4	6	5	1
			W50	9	10	10	6	7	5	5	3
	2		Q	1	10	8	4	4	5	1	2
			W56	2	10	10	10	8	7	8	4
			W50	3	10	10	10	10	7	3	7
			N56	4	10	7	6	7	7	5	5
			N50	5	10	10	8	6	4	3	2
			W36	6	10	10	8	8	3	6	1
			W30	7	10	9	8	5	4	3	3
			N36	8	10	10	9	6	3	5	4
			N30	9	10	6	6	6	4	4	2
10	1	28-8	W56	1	8	10	9	9	5	5	1
			W50	2	10	9	8	9	7	3	0
			N56	3	10	10	9	8	1	0	0
			N50	4	8	9	6	2	0	0	1
			W36	5	10	8	8	3	1	0	0
			W30	6	10	9	9	6	7	2	0
			N36	7	4	3	1	0	0	0	0
			N30	8	8	5	2	0	0	0	0
			Q	9	6	5	8	5	3	3	0
	2		Q	1	9	9	7	6	1	0	0
			N30	2	9	5	7	1	1	0	0
			N36	3	7	8	5	2	4	1	0
			W30	4	10	10	10	8	5	0	0
			W36	5	10	10	8	8	4	1	1
			N50	6	9	7	4	4	1	0	1
			N56	7	10	9	9	6	0	0	0
			W50	8	10	9	10	6	6	1	0
			W56	9	8	9	9	7	8	6	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
11	1	30-11	W50	1	10	7	8	3	4	3	4
			N56	2	10	9	2	5	1	1	0
			N50	3	10	8	7	4	2	0	0
			W36	4	10	7	7	4	5	2	0
			W30	5	8	9	8	6	1	1	1
			N36	6	8	7	6	1	1	0	0
			N30	7	9	8	5	3	2	0	0
			Q	8	8	9	7	4	2	1	0
			W56	9	10	10	7	3	1	1	0
	2		N30	1	10	5	1	0	0	0	0
			N36	2	8	8	3	1	0	0	0
			W30	3	8	9	8	3	0	0	1
			W36	4	10	10	7	4	5	3	0
			N50	5	9	7	9	3	2	1	0
			N56	6	9	7	2	2	2	0	1
			W50	7	10	8	8	5	3	0	0
			W56	8	10	9	7	9	5	2	0
			Q	9	9	7	2	3	0	0	0
12	1	40-0	N56	1	5	6	3	2	1	1	0
			N50	2	2	2	1	1	0	0	0
			W36	3	6	5	4	3	1	1	0
			W30	4	5	3	4	3	1	1	0
			N36	5	3	3	1	0	0	0	0
			N30	6	3	4	0	3	4	0	0
			Q	7	6	4	3	1	1	0	0
			W56	8	10	8	4	3	3	3	1
			W50	9	5	6	5	4	2	1	0
	2		N36	1	6	5	3	0	0	0	0
			W30	2	3	4	2	1	0	1	0
			W36	3	5	5	3	3	1	1	0
			N50	4	5	5	5	2	0	0	0
			N56	5	8	7	6	4	2	0	0
			W50	6	8	5	4	2	1	1	0
			W56	7	10	9	8	5	2	0	0
			Q	8	7	5	1	1	0	0	0
			N30	9	6	3	1	0	1	1	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
13	1	20-6	N50	1	6	7	7	2	1	0	0
			W36	2	9	8	6	8	4	3	1
			W30	3	9	8	8	7	3	1	0
			N36	4	8	10	6	6	3	1	0
			N30	5	10	10	6	6	2	1	0
			Q	6	10	6	4	4	4	2	0
			W56	7	10	10	5	6	5	5	3
			W50	8	8	10	6	3	2	0	0
			N56	9	9	6	4	2	0	0	0
	2		W30	1	10	7	7	7	4	4	0
			W36	2	9	8	3	4	5	4	0
			N50	3	8	6	4	5	4	2	1
			N56	4	3	3	0	0	0	0	0
			W50	5	10	10	9	6	5	1	1
			W56	6	8	7	5	6	6	0	0
			Q	7	8	7	7	7	5	1	0
			N30	8	7	8	6	5	5	2	0
			N36	9	9	5	4	2	0	0	0
14	1	26-4	W36	1	10	10	7	7	4	1	0
			W30	2	8	7	3	3	1	0	0
			N36	3	10	8	7	7	2	0	0
			N30	4	9	8	5	2	0	0	0
			Q	5	10	7	8	4	2	0	0
			W56	6	10	10	5	7	6	1	4
			W50	7	10	9	7	2	0	0	0
			N56	8	9	7	5	3	0	0	0
			N50	9	9	6	2	2	1	0	0
	2		W36	1	10	10	9	7	4	1	0
			N50	2	8	9	1	0	0	0	0
			N56	3	10	10	4	1	0	0	0
			W50	4	10	8	9	6	1	1	0
			W56	5	10	10	8	4	0	0	0
			Q	6	8	6	7	3	3	2	0
			N30	7	8	7	6	2	1	0	0
			N36	8	8	8	6	3	3	0	0
			W30	9	9	7	6	3	1	0	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
15	1	26-4	W30	1	10	10	10	7	4	2	1
			N36	2	8	8	5	5	7	5	4
			N30	3	9	9	9	7	7	7	5
			Q	4	8	9	7	8	5	3	0
			W56	5	10	10	7	7	4	5	0
			W50	6	10	9	9	9	6	8	5
			N56	7	10	8	8	3	0	0	0
			N50	8	9	9	3	1	1	0	0
			W36	9	10	10	10	10	7	2	0
	2		N50	1	8	7	5	1	5	1	1
			N56	2	10	8	7	6	7	3	0
			W50	3	10	9	8	3	1	2	0
			W56	4	10	9	9	6	4	3	0
			Q	5	10	9	9	8	5	2	0
			N30	6	9	9	6	6	6	1	0
			N36	7	10	9	8	8	2	3	1
			W30	8	10	10	9	9	5	5	3
			W36	9	10	8	9	6	3	4	2
16	1	23-6	N36	1	9	6	8	1	0	0	0
			N30	2	7	7	4	0	0	0	0
			Q	3	8	9	6	6	2	0	0
			W56	4	10	9	8	5	0	0	0
			W50	5	10	9	10	7	3	1	1
			N56	6	10	9	7	4	0	0	0
			N50	7	10	9	7	6	5	0	0
			W36	8	9	9	8	4	0	0	0
			W30	9	9	9	9	6	1	0	0
	2		N56	1	10	10	8	5	2	0	0
			W50	2	10	10	9	8	1	0	0
			W56	3	10	9	8	7	4	0	0
			Q	4	9	10	8	6	4	1	1
			N30	5	10	10	10	5	1	0	0
			N36	6	10	10	10	5	3	0	0
			W30	7	10	9	10	8	4	1	1
			W36	8	10	10	10	6	6	2	2
			N50	9	10	10	9	10	1	0	0

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
17	1	22-5	N30	1	4	3	0	0	0	0	0
			Q	2	8	7	6	5	4	1	0
			W56	3	10	8	7	5	7	4	0
			W50	4	10	10	8	3	7	4	0
			N56	5	6	7	7	5	6	3	1
			N50	6	8	8	5	4	4	3	1
			W36	7	10	6	7	8	3	1	0
			W30	8	6	6	2	0	0	0	0
			N36	9	6	5	2	1	0	0	0
	2		W50	1	10	7	8	4	6	3	1
			W56	2	10	8	8	7	8	7	3
			Q	3	8	6	7	7	3	1	0
			N30	4	8	2	2	2	0	0	1
			N36	5	2	1	2	0	0	0	0
			W30	6	10	9	5	5	5	0	0
			W36	7	10	7	10	6	7	4	1
			N50	8	2	5	1	2	0	0	0
			N56	9	2	2	2	2	0	0	0
18	1	23-2	Q	1	10	8	8	7	5	2	0
			W56	2	10	10	10	8	4	4	2
			W50	3	10	9	9	5	4	5	2
			N56	4	8	8	9	4	5	4	3
			N50	5	9	10	8	4	5	2	1
			W36	6	8	9	9	7	7	5	3
			W30	7	9	8	6	7	3	4	1
			N36	8	9	6	6	4	2	1	1
			N30	9	10	5	6	4	3	3	2
	2		W56	1	10	10	9	7	5	3	2
			Q	2	8	6	8	6	3	2	1
			N30	3	8	7	7	5	5	3	0
			N36	4	9	10	8	1	4	2	1
			W30	5	9	7	6	4	3	3	2
			W36	6	10	9	5	4	3	4	2
			N50	7	7	9	5	4	5	1	1
			N56	8	7	9	7	4	4	5	0
			W50	9	10	10	8	4	4	4	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB						
					1.6	1.4	1.2	1.0	.8	.6	.4
19	1	22-10	Q	1	10	10	5	4	1	0	0
			N30	2	8	3	2	1	0	0	0
			N36	3	6	2	2	1	1	0	0
			W30	4	7	6	5	3	0	0	0
			W36	5	8	8	6	8	5	1	0
			N50	6	3	2	3	1	0	0	0
			N56	7	6	5	4	3	0	0	0
			W50	8	10	8	8	5	0	1	0
			W56	9	10	8	6	4	1	1	0
	2		W56	1	10	8	4	2	1	0	1
			W50	2	10	7	5	2	0	0	0
			N56	3	7	2	1	1	0	0	0
			N50	4	5	3	3	2	0	0	0
			W36	5	5	5	2	1	0	0	0
			W30	6	6	3	3	0	0	0	0
			N36	7	5	4	3	0	0	0	0
			N30	8	4	0	0	0	0	0	0
			Q	9	8	8	2	2	0	1	0
20	1	23-0	N30	1	8	7	6	3	1	0	0
			N36	2	6	4	4	4	3	0	0
			W30	3	10	10	8	8	6	2	1
			W36	4	10	10	8	7	4	2	1
			N50	5	10	10	10	5	3	1	0
			N56	6	10	9	10	7	6	3	1
			W50	7	10	10	7	6	5	5	1
			W56	8	10	9	9	9	3	3	1
	2		W50	1	10	10	8	7	5	1	0
			N56	2	10	10	7	6	3	2	1
			N50	3	10	8	7	0	3	2	1
			W36	4	8	8	7	7	3	1	0
			W30	5	10	7	6	6	4	0	0
			N36	6	8	7	8	2	1	1	0
			N30	7	9	9	5	2	2	0	0
			Q	8	10	7	6	6	3	0	0
			W56	9	10	10	10	9	5	4	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
21	1	25-4	N36	1	10	4	4	1	0	0	0
			W30	2	10	10	5	4	5	1	0
			W36	3	10	6	7	4	6	0	0
			N50	4	9	6	5	1	0	0	0
			N56	5	5	5	4	1	1	0	0
			W50	6	8	10	6	6	4	5	2
			W56	7	7	10	6	8	4	3	0
			Q	8	8	6	3	5	0	0	0
			N30	9	9	10	7	4	5	3	0
	2		N56	1	10	6	6	6	1	0	0
			N50	2	6	6	4	2	0	0	0
			W36	3	10	9	5	4	4	1	0
			W30	4	10	7	8	5	5	1	0
			N36	5	6	7	5	4	0	0	0
			N30	6	5	8	6	2	0	1	1
			Q	7	8	8	5	5	3	1	1
			W56	8	8	8	7	6	5	4	0
			W50	9	8	8	7	5	6	2	1
22	1	25-7	W30	1	10	10	8	5	2	4	2
			W36	2	10	10	10	7	6	3	1
			N50	3	10	7	6	6	1	0	0
			N56	4	10	5	8	5	4	5	2
			W50	5	10	10	9	9	7	6	3
			W56	6	10	10	10	10	8	8	4
			Q	7	10	8	8	6	6	3	2
			N30	8	9	9	8	4	4	3	1
			N36	9	9	10	9	7	3	0	0
	2		N50	1	10	9	8	6	5	0	0
			W36	2	10	9	10	7	8	5	2
			W30	3	10	10	9	8	4	3	0
			N36	4	9	10	8	4	5	0	0
			N30	5	10	10	9	7	6	1	1
			Q	6	9	9	9	6	7	0	0
			W56	7	10	10	10	7	8	4	3
			W50	8	10	10	10	9	8	6	1
			N56	9	9	10	7	6	5	5	1

Raw Data (continued)

Subject	Day	Age	Masking	Order	1.6	1.4	1.2	1.0	.8	.6	.4
23	1	21-5	W36	1	9	6	4	2	0	0	0
			N50	2	8	5	5	3	5	0	0
			N56	3	9	7	6	1	0	0	0
			W50	4	10	9	9	7	3	1	1
			W56	5	9	7	8	6	2	0	1
			Q	6	9	7	8	5	4	0	0
			N30	7	8	6	6	1	0	0	0
			N36	8	6	5	3	5	0	0	0
			W30	9	10	5	7	2	1	0	0
	2		W36	1	6	6	4	2	0	0	0
			W30	2	9	7	2	1	0	0	0
			N36	3	8	4	0	0	0	0	0
			N30	4	9	7	4	0	0	0	0
			Q	5	9	3	4	5	2	0	0
			W56	6	10	9	7	5	2	1	0
			W50	7	10	10	9	5	3	3	1
			N56	8	10	8	3	3	1	0	0
			N50	9	9	8	7	3	3	0	0
24	1	27-4	N50	1	8	5	5	4	0	0	0
			N56	2	8	6	7	2	0	0	0
			W50	3	10	10	8	10	5	2	1
			W56	4	10	8	6	7	4	3	0
			Q	5	8	9	5	5	4	2	0
			N30	6	8	7	6	3	2	1	0
			N36	7	8	8	9	7	2	1	0
			W30	8	10	9	6	6	5	0	1
			W36	9	10	10	9	6	4	5	2
	2		W30	1	10	10	9	8	6	2	1
			N36	2	9	8	10	8	4	0	0
			N30	3	9	9	7	5	1	0	0
			Q	4	9	10	8	6	3	2	1
			W56	5	10	8	7	8	8	4	1
			W50	6	10	10	8	6	4	2	0
			N56	7	9	10	9	6	8	4	0
			N50	8	10	8	5	3	1	1	1
			W36	9	10	10	9	7	8	2	0

Increment Size in dB applies to columns 1.6 through .4.

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
25	1	24-2	N56	1	8	9	9	5	6	2	0
			W50	2	10	10	7	8	1	0	0
			W56	3	9	10	9	10	6	2	1
			Q	4	10	10	5	6	1	0	1
			N30	5	9	9	4	4	0	0	0
			N36	6	9	7	9	5	0	0	0
			W30	7	10	9	6	6	3	0	0
			W36	8	10	10	8	8	4	3	1
			N50	9	9	8	8	5	4	0	0
	2		N36	1	10	10	7	6	3	1	0
			N30	2	10	9	5	6	3	0	0
			Q	3	10	10	7	6	1	1	0
			W56	4	10	10	9	9	4	4	2
			W50	5	10	10	10	7	4	3	1
			N56	6	8	10	4	6	2	1	0
			N50	7	10	8	5	5	4	0	0
			W36	8	10	10	7	6	2	2	0
			W30	9	9	9	9	4	5	4	1
26	1	37-2	W50	1	8	9	9	4	4	0	0
			W56	2	9	10	9	2	0	0	0
			Q	3	8	6	2	1	0	0	0
			N30	4	9	9	9	6	0	0	0
			N36	5	9	10	9	7	2	0	0
			W30	6	10	9	8	6	0	0	0
			W36	7	8	9	5	4	0	0	0
			N50	8	9	8	5	0	0	0	0
			N56	9	6	7	5	4	0	0	0
	2		N30	1	10	10	8	2	0	0	0
			Q	2	10	9	6	1	0	0	0
			W56	3	10	10	10	9	7	2	0
			W50	4	10	10	10	10	6	0	0
			N56	5	10	9	8	6	1	0	0
			N50	6	7	9	10	2	1	0	0
			W36	7	10	9	10	6	7	1	0
			W30	8	10	8	9	9	2	0	0
			N36	9	9	8	5	1	0	0	0

Subject	Day	Age	Masking	Order	1.6	1.4	1.2	1.0	.8	.6	.4
					Increment Size in dB						
27	1	19-7	W56	1	9	5	7	3	3	2	1
			Q	2	9	9	6	5	2	0	0
			N30	3	7	6	2	1	0	0	0
			N36	4	4	3	1	0	0	0	0
			W30	5	9	9	7	9	3	1	1
			W36	6	10	7	5	8	5	0	0
			N50	7	9	3	1	0	0	0	0
			N56	8	9	9	7	5	2	0	0
			W50	9	9	9	7	7	4	2	0
	2		Q	1	9	9	5	4	1	0	1
			W56	2	9	8	7	4	4	2	1
			W50	3	7	7	8	4	6	1	0
			N56	4	6	7	7	4	1	0	0
			N50	5	5	3	0	0	0	0	0
			W36	6	8	6	6	4	2	3	1
			W30	7	7	5	7	6	6	1	0
			N36	8	6	1	2	1	0	0	0
			N30	9	10	10	4	4	0	0	0
28	1	28-8	W56	1	10	10	10	9	7	2	0
			W50	2	10	10	10	9	5	2	1
			N56	3	10	9	7	5	3	1	0
			N50	4	9	9	7	6	4	1	1
			W36	5	10	9	10	6	4	2	1
			W30	6	8	9	6	3	2	0	0
			N36	7	9	10	9	4	2	0	0
			N30	8	8	8	6	2	0	0	0
			Q	9	10	8	7	4	1	0	0
	2		Q	1	9	9	7	4	1	0	0
			N30	2	10	8	5	2	0	0	0
			N36	3	10	9	6	4	1	0	0
			W30	4	10	9	8	9	5	0	0
			W36	5	10	9	10	10	0	0	1
			N50	6	8	8	5	6	0	0	0
			N56	7	10	7	4	3	0	0	0
			W50	8	10	7	6	5	3	0	0
			W56	9	10	10	8	6	4	0	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	1.6	1.4	1.2	1.0	.8	.6	.4
					Increment Size in dB						
29	1	23-0	W50	1	10	9	10	9	7	7	1
			N56	2	10	10	9	5	2	0	0
			N50	3	9	7	7	9	1	0	0
			W36	4	10	9	10	8	5	3	0
			W30	5	10	9	9	9	5	2	1
			N36	6	9	9	3	2	1	1	0
			N30	7	10	7	7	2	1	0	0
			Q	8	9	8	8	6	1	0	0
			W56	9	10	10	10	7	6	5	1
	2		N30	1	8	7	9	6	2	1	1
			N36	2	9	10	9	5	4	0	0
			W30	3	10	9	7	9	3	0	0
			W36	4	10	10	9	10	4	3	1
			N50	5	8	4	2	4	1	1	0
			N56	6	10	9	5	6	0	0	0
			W50	7	10	10	10	8	8	6	2
			W56	8	10	10	9	10	7	5	1
			Q	9	10	10	9	3	2	1	1
30	1	22-0	N56	1	7	8	4	5	3	0	0
			N50	2	7	7	6	6	2	0	0
			W36	3	10	10	9	6	1	0	0
			W30	4	9	10	7	9	4	2	1
			N36	5	9	10	7	5	2	0	1
			N30	6	10	8	4	3	1	0	0
			Q	7	10	7	6	5	1	0	0
			W56	8	10	10	9	4	7	6	0
			W50	9	10	6	5	5	6	7	1
	2		N36	1	8	9	7	6	2	0	0
			W30	2	10	9	10	9	3	2	1
			W36	3	10	10	8	7	7	0	0
			N50	4	10	10	9	7	2	0	0
			N56	5	10	10	8	7	4	0	0
			W50	6	10	10	10	9	6	6	2
			W56	7	10	10	10	9	8	4	2
			Q	8	10	10	9	7	5	3	0
			N30	9	10	6	5	2	1	1	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
31	1	21-8	N50	1	7	6	3	1	0	0	0
			W36	2	8	6	2	2	1	0	0
			W30	3	7	4	3	2	0	1	0
			N36	4	3	2	0	0	0	0	0
			N30	5	5	2	1	0	0	0	0
			Q	6	4	5	3	0	0	0	0
			W56	7	9	7	7	4	1	0	0
			W50	8	8	5	1	1	0	0	0
			N56	9	3	2	0	0	0	0	0
	2		W30	1	10	10	10	4	1	1	0
			W36	2	10	10	8	7	0	0	0
			N50	3	9	9	6	2	0	0	0
			N56	4	4	5	3	3	0	0	1
			W50	5	10	9	6	6	1	0	0
			W56	6	10	9	8	9	4	3	1
			Q	7	5	5	6	2	0	0	0
			N30	8	6	3	0	0	0	0	0
			N36	9	7	6	5	3	2	0	0
32	1	37-0	W36	1	9	8	6	5	2	0	0
			W30	2	8	5	5	5	2	0	0
			N36	3	5	7	5	1	0	0	0
			N30	4	5	6	3	1	1	0	0
			Q	5	9	8	5	3	1	0	0
			W56	6	8	7	8	5	5	2	0
			W50	7	8	9	8	7	3	0	0
			N56	8	7	6	5	3	0	0	0
			N50	9	4	1	0	0	0	0	0
	2		W36	1	8	6	4	2	0	0	1
			N50	2	2	2	1	0	0	1	1
			N56	3	7	5	3	3	0	0	0
			W50	4	9	8	4	4	1	1	0
			W56	5	8	8	8	6	3	1	0
			Q	6	5	4	4	2	0	1	1
			N30	7	4	2	1	0	1	0	0
			N36	8	4	2	0	0	0	0	0
			W30	9	6	3	3	1	2	0	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB 1.6	1.4	1.2	1.0	.8	.6	.4
33	1	23-9	W30	1	8	9	10	8	2	0	0
			N36	2	7	5	6	3	0	0	0
			N30	3	7	8	4	1	1	0	1
			Q	4	10	8	7	3	1	0	0
			W56	5	10	10	8	7	2	1	1
			W50	6	10	9	6	6	2	0	0
			N56	7	10	9	8	9	5	0	0
			N50	8	8	6	4	0	0	0	0
			W36	9	8	7	7	4	1	0	0
	2		N50	1	10	5	5	5	0	0	0
			N56	2	9	7	6	5	1	0	0
			W50	3	10	8	7	5	5	2	1
			W56	4	10	9	9	9	5	4	0
			Q	5	8	6	6	3	1	0	0
			N30	6	10	3	4	3	1	0	0
			N36	7	8	2	4	4	0	0	0
			W30	8	9	9	8	7	5	1	1
			W36	9	9	9	9	5	4	0	0
34	1	34-9	N36	1	2	0	0	0	0	0	0
			N30	2	3	4	1	0	0	0	0
			Q	3	5	5	5	1	0	1	0
			W56	4	9	7	6	2	2	0	0
			W50	5	9	6	5	1	0	0	0
			N56	6	9	6	7	2	0	0	0
			N50	7	6	2	1	0	0	0	0
			W36	8	7	7	2	0	0	0	0
			W30	9	8	9	9	4	1	0	0
	2		N56	1	9	6	4	3	0	0	0
			W50	2	9	5	5	4	2	0	1
			W56	3	10	8	6	3	1	0	0
			Q	4	8	6	4	1	0	0	0
			N30	5	7	8	3	0	0	0	0
			N36	6	5	4	4	3	0	0	0
			W30	7	8	7	4	2	1	0	0
			W36	8	7	7	5	4	1	0	0
			N50	9	9	3	0	1	0	0	0

Raw Data (continued)

Subject	Day	Age	Masking	Order	Increment Size in dB						
					1.6	1.4	1.2	1.0	.8	.6	.4
35	1	25-3	N30	1	8	9	10	7	6	1	1
			Q	2	9	8	5	5	3	1	1
			W56	3	10	8	8	8	3	2	2
			W50	4	10	9	8	6	5	2	1
			N56	5	7	5	5	3	0	0	0
			N50	6	5	6	4	1	2	0	1
			W36	7	10	7	9	4	2	0	0
			W30	8	10	8	6	4	5	0	1
			N36	9	10	6	5	3	0	0	0
	2		W50	1	10	10	10	9	7	0	0
			W56	2	10	10	10	10	6	3	2
			Q	3	8	9	7	4	3		1
			N30	4	10	8	8	5	2	1	0
			N36	5	10	10	10	8	5	0	0
			W30	6	10	10	10	8	2	1	1
			W36	7	10	10	9	9	9	5	4
			N50	8	10	9	9	7	5	1	0
			N56	9	10	10	8	5	4	1	1
36	1	36-3	Q	1	10	9	9	7	1	0	0
			N30	2	10	10	10	4	0	0	0
			N36	3	7	9	7	1	0	0	0
			W30	4	10	9	10	6	5	4	2
			W36	5	10	10	9	5	1	0	0
			N50	6	9	10	10	4	2	1	0
			N56	7	9	8	8	2	0	0	0
			W50	8	10	10	9	8	5	0	0
			W56	9	10	10	10	9	5	6	2
	2		W56	1	10	10	10	8	8	6	3
			W50	2	10	10	9	7	3	1	0
			N56	3	9	8	9	6	1	0	0
			N50	4	10	10	7	8	2	0	0
			W36	5	10	10	9	7	5	3	1
			W30	6	10	8	3	6	2	2	1
			N36	7	8	6	4	3	1	0	1
			N30	8	10	9	8	7	4	0	0
			Q	9	10	10	8	8	1	0	0

APPENDIX C

WHOLLY SIGNIFICANT TEST RESULTS

Table C-1

WSD Results on the Main Effect: Contralateral Masking
(Collapsed Over Increment Size and Test Day)

	Masking Conditions								
	N36	N50	N30	N56	Q	W30	W36	W50	W56
Mean Number of Increments Detected	3.95	3.99	4.11	4.36	4.56	5.10	5.40	5.78	5.99

Table C-2

WSD Results on the Simple Effects of the Increment
Factor at Nine Levels of Masking
(Number of Observations = 72; CV = .95)

Masking Condition	Increment Size (.4)	(.6)	(.8)	(1.0)	(1.2)	(1.4)	(1.6)
Q	.29	1.24	2.79	4.88	6.33	7.75	8.67
N30	.42	1.11	2.18	3.65	5.64	7.31	8.43
N36	.49	.81	2.21	3.76	5.65	6.92	7.83
N30	.78	1.57	3.42	5.74	7.04	8.14	9.10
W36	.69	1.97	3.82	5.97	7.56	8.53	9.29
N50	.38	.74	2.10	3.79	5.51	7.22	8.24
N56	.49	1.18	2.21	4.38	6.13	7.65	8.53
W50	1.10	2.44	4.36	6.25	7.92	8.85	9.57
W56	1.01	2.97	4.68	6.64	7.99	9.04	9.61

Table C-3

WSD Results on the Simple Effects of the Factor: Contralateral Masking at the Seven Levels of Increment Size (Number of Observations = 72; CV = .875)

Increment Size	Masking Conditions								
	N36	N50	N30	N56	Q	W30	W36	W50	W56
1.6	7.83	8.24	8.43	8.53	8.67	9.10	9.29	9.57	9.61
1.4	6.92	7.22	7.31	7.65	7.75	8.14	8.53	8.85	9.04
1.2	5.51	5.64	5.65	6.13	6.33	7.04	7.56	7.92	7.99
1.0	3.65	3.76	3.79	4.38	4.88	5.74	5.97	6.25	6.64
0.8	2.10	2.18	2.21	2.21	2.79	3.42	3.82	4.36	4.68
0.6	0.74	0.81	1.11	1.18	1.24	1.57	1.97	2.44	2.97
	Q	N50	N30	N36	N56	W36	W30	W56	W50
0.4	0.29	0.38	0.42	0.49	0.49	0.69	0.78	1.01	1.10

APPENDIX D

MEAN CONTRASTS

Table D-1

All Possible Mean Contrasts of the Increments Identified for Increment Size Over Masking Condition and Test Day (Number of Observations = 648)

	Contrast	Difference	Obtained T statistic	DF value	Critical value of T	Lower limit	Upper limit	Significance
1	1.6-1.4	0.8688	10.155	35	3.13	0.6014	1.1362	*
2	1.6-1.2	2.1620	17.365	35	3.13	1.7729	2.5512	*
3	1.6-1.0	3.7994	24.734	35	3.13	3.3193	4.2795	*
4	1.6-0.8	5.7176	30.053	35	3.13	5.1230	6.3122	*
5	1.6-0.6	7.2438	36.379	35	3.13	6.6215	7.8662	*
6	1.6-0.4	8.1759	48.639	35	3.13	7.6506	8.7013	*
7	1.4-1.2	1.2932	15.776	35	3.13	1.0370	1.5494	*
8	1.4-1.0	2.9306	25.002	35	3.13	2.5642	3.2969	*
9	1.4-0.8	4.8488	26.487	35	3.13	4.2766	5.4209	*
10	1.4-0.6	6.3750	29.139	35	3.13	5.6912	7.0588	*
11	1.4-0.4	7.3071	34.142	35	3.13	6.6382	7.9760	*
12	1.2-1.0	1.6373	16.034	35	3.13	1.3182	1.9565	*
13	1.2-0.8	3.5556	19.890	35	3.13	2.9968	4.1143	*
14	1.2-0.6	5.0818	22.388	35	3.13	4.3724	5.4209	*
15	1.2-0.4	6.0139	25.249	35	3.13	5.2695	6.7583	*
16	1.0-0.8	0.9182	15.180	35	3.13	1.5233	2.3132	*
17	1.0-0.6	3.4440	17.926	35	3.13	2.8439	4.050	*
18	1.0-0.4	4.3765	18.884	35	3.13	3.6522	5.1009	*
19	0.8-0.6	1.5262	12.797	35	3.13	1.1535	1.8990	*
20	0.8-0.4	2.4583	12.779	35	3.13	1.8571	3.0596	*

*Indicates significance greater than .05.